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OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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COMING MEETINGS OF THE SOCIETY

October 14, *New York City*, Engineering Societies Building. Paper: Stability in Aeronautics, A. A. Merrill.

October 16, *Cincinnati, Ohio.* Paper: Stresses in Machine Frames, A. Lewis Jenkins.

October 17, *Worcester, Mass.*, Worcester Polytechnic Institute. Papers: Experiments with Aeroplane Propellers, David L. Gallup; Modern Abrasives, Their Manufacture and Use, Aldus C. Higgins, George Jeppson, Charles H. Norton. For further details, see page 5.

November 19, *New Haven*, Mason Laboratory, Sheffield Scientific School. Subjects: Industrial Coöperative Research, and miscellaneous papers.

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ANNUAL MEETING

The Committee on Meetings have arranged a tentative program for the Annual Meeting which is published herewith. The titles of papers are given so far as possible at this early date, and in several cases where papers are still in preparation, the subjects decided upon by the committees in charge of the sessions are announced. A feature of the meeting will be the presentation of the Grasshof Medal, which was placed in the hands of the Society to deliver to its Past-President, George Westinghouse, at the notable Leipzig meeting. Another event of interest which it is expected will be largely attended is the German Dinner scheduled for Thursday evening of the meeting, at which one of the menus of the German trip will be reproduced and addresses will be given with lantern slides upon incidents of the trip.

TENTATIVE PROGRAM

Tuesday Evening, December 2

PRESIDENT'S RECEPTION.

Wednesday Morning, December 3

BUSINESS MEETING, followed by professional session with the following papers:

EFFICIENCY OF ROPE DRIVING AS A MEANS OF POWER TRANSMISSION, E. H. Ahara

COMPARATIVE TESTS OF LINESHAFT BEARINGS, Carl C. Thomas, E. R. Maurer and L. E. Kelso

THE ART OF ENAMELING, OR THE COATING OF STEEL AND IRON WITH GLASS, Raymond F. Nailler

STABILITY IN FLYING MACHINES, Albert A. Merrill (contributed by the New York Local Committee)

Wednesday Afternoon

RAILROAD SESSION, with papers on Steel Freight Cars (contributed by the Sub-Committee on Railroads)

Wednesday Evening

Presentation by the Verein deutscher Ingenieure of the Grasshof Medal, to George Westinghouse, Past-President and Honorary Member, Am.Soc.M.E.

Arrangements are being made for a lecture to follow the ceremony of presentation, announcement of which will be made later.

Thursday Morning, December 4

PROFESSIONAL SESSION, with the following papers:

PITOT TUBES FOR GAS MEASUREMENT, W. C. Rowse

TESTS OF VACUUM CLEANING SYSTEMS, J. R. McColl

TESTS UPON THE TRANSMISSION OF HEAT IN VACUUM EVAPORATORS, E. W. Kerr

A NEW CENTRIFUGAL PUMP WITH HELICOIDAL IMPELLER, C. V. Kerr (contributed by the New York Local Committee)

A NEW PROCESS OF CLEANING PRODUCER GAS, H. F. Smith (contributed by the Gas Power Section)

Arrangements are also being made for simultaneous sessions on Machine Shop Practice, Cement Manufacture, and Textiles, by the sub-committees in charge of these subjects.

At the MACHINE SHOP SESSION, among the topics to be discussed are: Use of Gears in Machine Tool Drives, Grouping of Machine Tools, Cast Iron for Machine Tools, Flooded Lubrication and Force Fits.

The discussion at the CEMENT SESSION will cover the Use of Powdered Fuel and other subjects to be announced later.

The TEXTILE SESSION will take up Cost Finding and General Efficiency, Heating Buildings through the Sprinkler System, and Fire Escapes as applied to Textile Mills.

Thursday Afternoon

Excursions to points of interest in New York and vicinity.

Thursday Evening

GERMAN DINNER, reproducing one of the menus from the trip abroad. This will not only be a reunion of those who went on the trip, but is being arranged with a view to giving those who were unable to participate some idea of the many interesting events which the American guests enjoyed. Addresses on the German trip will be made, illustrated by lantern slides.

Following the dinner a DANCE will probably be arranged for.

Friday Morning, December 5

Session on FIRE PROTECTION.

Among the subjects to be discussed are the Management of Valves controlling Automatic Sprinkler Heads, Extinguishing of Fires in Oils and

Volatile Liquids, and the Fire Hazard in Turbo-Generators. Contributed by the Sub-Committee on Fire Protection.

Friday Evening

COLLEGE REUNIONS. It has been the custom for the alumni of certain of the technical schools to hold reunions in New York at about this time of the year, and an opportunity will be offered for such gatherings on this evening. The alumni of Stevens Institute of Technology are arranging for a theater party, to which the Society and their guests are invited. Supper and informal dancing at a convenient hotel will follow. The alumni of Sheffield Scientific School will arrange a similar reunion, details of which will be given later.

MEETING IN WORCESTER

The meeting in Worcester, Mass., will be held on October 17, instead of October 10 as originally announced, and will have the following program. Boston members of the Society will leave for Worcester on the noon train from South Station, Boston, due at 1.04 p.m., and will be conveyed to the Worcester Polytechnic Institute by automobile. Luncheon will be served and an opportunity afforded for an inspection of the Institute buildings and equipment. At 2.30 the guests may either attend a lecture by Professor Gallup on Experiments with Aeroplane Propellors, followed by an inspection of aeroplane tests at a point a few miles from Worcester, or may visit any of the following industrial establishments: Grafton & Knight Manufacturing Company, Crompton & Knowles Loom Works, American Steel & Wire Company, Worcester Pressed Steel Company, Worcester Electric Light Company, United States Envelope Company, Heald Machine Company, Reed & Prince Manufacturing Company, or Osgood Bradley Car Company.

The party will reassemble at the Norton Company works at 4 o'clock, and papers upon Modern Abrasives, their Manufacture and Use, by Aldus C. Higgins, George Jeppson and Charles H. Norton, will be delivered. An inspection will then be made of the plant. Dinner will be served at 7 o'clock at the New Bancroft Hotel, at $1.50 per plate. This will be an entirely informal affair and brief talks will be made by Charles G. Washburn and James Logan on topics connected with the Worcester industries. Boston members will return on the 9.42 train due at 10.45, and in case the number who desire to attend is large enough, arrangements will be made for special trains both to and from Worcester. Those who cannot take in the entire program will be welcomed for such time as they can spend.

REPORT OF THE NOMINATING COMMITTEE

The Secretary announces the receipt of the following report from the Nominating Committee, consisting of John R. Freeman, chairman, Chas. T. Main, Thomas Morrin, Fred. Sargent, and C. C. Thomas: For President, James Hartness, Springfield, Vt.; Vice-Presidents (for two years), Henry L. Gantt, New York City, E. E. Keller, Detroit, Mich., H. G. Reist, Schenectady, N. Y.; Managers (for three years), A. M. Greene, Jr., Troy, N. Y., John Hunter, St. Louis, Mo., Elliot H. Whitlock, Cleveland, Ohio; Treasurer, Wm. H. Wiley, New York City.

CURRENT AFFAIRS OF THE SOCIETY

The attention of the membership is called to the increasing number of meetings of the Society held in the several cities of the Union. It is the cordial desire of the Council that these meetings shall be extended wherever the members are willing to organize and carry on these activities, the Society being ready to finance the undertaking under appropriation by the Council upon the request of the local members interested. Further particulars will be furnished by the Secretary. The Council is anxious to have the membership feel that the Society is of direct benefit to each one individually, and an officer of the Society will be pleased to assist in the organization of such meetings or to visit groups already organized at any time.

INTERNATIONAL ENGINEERING CONGRESS 1915

Invitations emanating from the five national engineering societies of America have been issued to the principal societies of the world by the San Francisco general committee, of which Prof. W. F. Durand and William A. Cattell are respectively chairman and secretary. Col. Geo. W. Goethals will be Honorary President of the Congress, and the third week in September 1915 has been chosen as the date. It is hoped that the invitations issued will be generally accepted, and especially that our friends in Europe with whom the members have formed such close relationships will attend in a body and permit the American engineers to return in part the many hospitalities which have been enjoyed abroad.

DR. GOSS'S NEW UNDERTAKING

The President of the Society, Dr. W. F. M. Goss, Dean of the engineering department of the University of Illinois, has been

granted a leave of absence for one year, in order that he may accept the chairmanship of a commission appointed by the City of Chicago to work out a solution of the problem of smoke abatement in that city and of the electrification of the terminal facilities of all the railroads centering in Chicago.

LIBRARY SEARCHES

The value of library service to every member of the Society cannot be too often stated. We have one of the largest technical libraries on the continent, containing besides its many volumes 700 technical periodicals, and having a staff of six librarians available for the particular benefit of members living at a distance from headquarters. Every inquiry receives prompt attention and is free of expense except for extraordinary services, for which members are naturally glad to pay.

CALVIN W. RICE, *Secretary.*

CORRECTED DISCUSSION BY SANFORD E. THOMPSON

In the published discussion upon the Boston meeting of last March, which appeared in The Journal for June, the abstract of the remarks made by Mr. Sanford E. Thompson gives an entirely erroneous impression of the views actually expressed. We therefore publish the paragraph properly corrected. The subject under discussion was Concrete Floors and Their Wearing Qualities. Mr. Thompson stated that while concrete floors generally showed wear under trucking they could be built to withstand it successfully. He referred to a test which he had made in order to determine what precautions were necessary to provide good wearing qualities and pointed out the fact that an especially good floor surface would wear glossy and would not dust; while a poor surface would wear down to a dead white color. Sand for surfacing should be coarse.

APPLICATIONS FOR MEMBERSHIP

The Membership Committee have received applications from the following candidates. Any member objecting to the election of any of these candidates should inform the Secretary before November 15, 1913:

ACKLAND, H. B., New York, N. Y.
ALDWORTH, EDWARD H., Montreal, Canada
ALLMAN, JOHN H., Butler, Pa.
AMMEN, FRANCIS DUP., New York, N. Y.
ANDERSON, PELLE, Milwaukee, Wis.
ARNOLD, JOHN A., Stamford, Conn.
AVRAM, MOIS H., New York, N. Y.
BABCOCK, SYLVESTER, Wilkinsburg, Pa.

Bates, Charles J., Jr., Highwood, N. J.
Baumgartner, Chas. G., Chicago, Ill.
Bebb, J. C., San Francisco, Cal.
Becker, Luther, Schuylkill Haven, Pa.
Bendt, Ernest R., Kenosha, Wis.
Benson, Carl H., San Francisco, Cal.
Bethel, Joseph N., Woonsocket, R. I.
Blee, Harry H., Sacramento, Cal.
Blessing, George F., Swarthmore, Pa.
Bonham, H. G., Pulaski, Va.
Borden, Moro M., Collingswood, N. J.
Bott, George R., New York, N. Y.
Breckenridge, Andrew L., Providence, R. I.
Briggs, Lester G., St. Johnsbury, Vt.
Brown, Rezeau B., Milwaukee, Wis.
Browne, Frank Atwood, Wheeling, W. Va.
Bullock, Wm. E., Philadelphia, Pa.
Callan, Wm. H., Franklin, Pa.
Campbell, Robert D., Hoboken, N. J.
Carpenter, Ralph E., Woonsocket, R. I.
Clark, Addison L., La Grange, Ill.
Cocks, Frank L., Brooklyn, N. Y.
Copland, Alex. W., Detroit, Mich.
Cowen, Harry, New York, N. Y.
Coyle, Andrew M., New York, N. Y.
Custer, Levitt L., Dayton, Ohio
Daniel, Thomas L., Robbinsdale, Minn.
Davenport, Wm. S., New Bedford, Mass.
David, Wm. H., Tottenville, N. Y.
Davis, Francis P., Providence, R. I.
Davis, Herman H., Boston, Mass.
Day, Charles H., E. Cleveland, Ohio
Deily, Arthur T., Perkasie, Pa.
Dempwolf, Charles J., Paterson, N. J.
Devens, Richard, New York, N. Y.
Dodgson, John K., Paterson, N. J.
Dombrowsky, Walter F., Newark, N. J.
Donovan, Wm. J., New York, N. Y.
Dorman, Neal W., Toledo, Mich.
Dreffein, Henry A., Chicago, Ill.
Duff, Philip J., New York, N. Y.
Dunn, Edward L., Worcester, Mass.
Eckert, Arthur C., St. Louis, Mo.
Eckfeldt, John J., Latrobe, Pa.
Edwards, J., Detroit, Mich.
Ellenwood, Frank Oakes, Ithaca, N. Y.
Evans, Cadwallader, Jr., Stellarton, N. S.
Farr, Roy S., Tampico Mexico
Farrell, Frederick L., New York, N. Y.
Field, Allan B., Pittsburgh, Pa.
Finlayson, Edward H., Jr., New York, N. Y.
Flanigan, Edwin B., Wilkesbarre, Pa.
Flinn, Melville S., Chicago, Ill.
Flory, John H., Columbus, Ohio
Flowers, H. Fort, New York, N. Y.
Fowden, Wm., Concrete, Colo.
Freeman, W. J., Madison, Wis.
Freshney, Samuel A., Grand Rapids, Mich.
Fuller, Henry J., New York, N. Y.
Gilbert, Harold A., New York, N. Y.
Goddard, Archibald N., Athol, Mass.
Goldthwaite, Harry W., Easton, Pa.
Gottfried, Carl M., Chicago, Ill.
Graburn, Arthur L., Toronto, Canada
Grace, Edward S., New York, N. Y.
Grauten, Sylvester H., Gatun, C. Z.
Gurney, E. R., Springfield, Mass.
Hammer, Edwin W., New York, N. Y.
Hare, Charles R., Hartford, Conn.
Harleman, Samuel T., Bethlehem, Pa.
Harris, Ford W., Los Angeles, Cal.
Hayward, Harold A., New York, N. Y.
Hill, Monroe R., Great Falls, Mont.
Hovey, Otis E., New York, N. Y.
Hunter, E. E., Oklahoma City, Okla.
Johnson, Henry W., Bridgeport, Conn.
Jones, Wm. B., Stamford, Conn.
Keating, D. A., Bridgeport, Conn.
Keep, Henry, New York, N. Y.
Klausmeyer, David C., Cincinnati, Ohio
Klein, George F., Kansas City, Mo.
Klotz, Harry J., Troy, N. Y.
Koch, Henry, Rahway, N. J.
Koepel, Edward, Beacon Hill, Mich.
Krause, Albert C., Sparrows Point, Md.
Lakey, Arthur B., New London, Conn.
Lask, Frederick, New York, N. Y.
Lawatsch, Frank R., Lehigh Gap, Pa.
Lee, Wallace R., Havana, Cuba
Leonard, Chas. S., Albany, N. Y.
Lewis, Fitz James, Empire, C. Z.
Lister, Alfred, Newark, N. J.
Logan, Maurice H., Jersey City, N. J.
Lowell, George C., Gary, Ind.
Luckenbach, Owen F., Oil City, Pa.
Luhn, Clarence W., Cincinnati, Ohio
McConnell, Robert S., Philadelphia, Pa.
McCormick, Edmund B., Washington, D. C.
McIlvrid, James, Jersey City, N. J.
McIntosh, Robert, Calumet, Mich.
McKee, William N., Fitchburg, Mass.
McMillan, Luther B., New Braunfels, Texas
Magie, Wm. E., Evansville, Ind.
Maginnis, Wm. S., Connellsville, Pa.
Mahood, David M., Jr., Brooklyn, N. Y.
Mark, Perry C., Zanesville, Ohio
Mathewson, Frank E., Jersey City, N. J.
Maurer, Daniel A., Fairmont, W. Va.
Mawson, Robert, New York, N. Y.
Messenger, Robert P., Brussels, Belgium
Mickle, Frank A., Columbus, Ohio
Millane, Rupert F., Melbourne, Australia
Miller, C. D. S., Bridgeport, Conn.
Mills, Wallace C., Janesville, Wis.
Moody, Frederick H., Toronto, Canada
Moore, E. A., Springfield, Mass.
Moyer, Wm. J., Brooklyn, N. Y.
Myers, James L., New York, N. Y.
Nichols, Charles K., New York, N. Y.
Noble, Wm. A. E., Los Angeles, Cal.
Nordin, Arvid, Chicago, Ill.
Oakley, Walter W., Kokomo, Ind.
Omdal, Torgeir, New York, N. Y.
Palsgrove, Grant K., Troy, N. Y.

PARKER, ROY T., Harvey, Ill.
PERKINS, NATHAN W., JR., Newark, N. J.
PETERSON, EDWARD J., Worcester, Mass.
PETTINOS, GEORGE F., Bethlehem, Pa.
PRIOR, WILBUR C., Forestville, Conn.
PUTNAM, J. RUSSELL, Waterbury, Conn.
QUINTANA, ERNESTO P., Havana, Cuba
RAU, FRANK B., Westfield, Mass.
REUTER, FRANCIS J. G., Chicago, Ill.
ROBINSON, EDWIN A., Meriden, Conn.
ROGERS, CHARLES M., Meridian, Miss.
ROOS, DELMAR G., Bridgeport, Conn.
ROSBOROUGH, CALDWELL R., Moline, Ill.
ROSS, FRANK E., Oakland, Cal.
RUSSELL, THOMAS N., Chicago, Ill.
SANDMAN, AUGUST G., Baltimore, Md.
SCHEDIN, P. H., Philadelphia, Pa.
SCHIFFL, CHARLES, Montclair, N. J.
SCHOLEFIELD, CRIGHTON W., San Francisco,Cal
SCHUBERT, ARNO, New Britain, Conn.
SELLEW, WELLES H., New York, N. Y.
SERBELL, CARL V., Portsmouth, Va.
SHELDON, LUCIAN A., Schenectady, N. Y.
SKINKLE, JAY W., Chicago, Ill.
SLUSS, ALFRED H., Lawrence, Kansas
SMEALLIE, JOHN M., Brooklyn, N. Y.
SMITH, HERBERT J., Greenfield, Mass.
SPENCER, IRA H., Hartford, Conn.
STEWART, HARRY M., Cincinnati, Ohio
STRAUB, THEODORE A., Pittsburgh, Pa.
SUTTON, GEORGE Z., Philadelphia, Pa.
SWOPE, BRUCE M., Oakmont, Pa.
SZYMANSKI, CASIMIR E., Sacramento, Cal.
TALBOT, HARRY J., New London, Conn.
TENKONOHY, FRANKLIN V., West Detroit, Mich.
THOMAS, WM. R., Pittsfield, Mass.
TROTTER, ARTHUR H., Anyox, Canada
TRUITT, R. MARSHALL, Germantown, Pa.
TYNG, ARTHUR, Ashland, N. H.
VAN DER WERFF, J. N., Toronto, Canada
WADDELL, JOSEPH A., JR., Worcester, Mass.
WADE, NORMAN S., Salem Depot, N. H.
WAIT, J. RUSSEL, Charles, S. C.
WALL, HAROLD M., Memphis, Tenn.
WALSH, W. J., Chicago, Ill.
WARREN, RALPH H., Easton, Pa.
WEBER, PETER, Newark, N. J.
WESTCOTT, ARTHUR L., Columbus, Mo.
WHITE, E. FIELD, Mansfield, Ohio
WHITEHEAD, RICHARD H., Miraflores, C. Z.
WHITNEY, AMOS, Hartford, Conn.
WHITNEY, WM. F., Ansonia, Conn.
WILLIAMS, FRANK D., New York, N. Y.
WOTHERSPOON, WM. L., New York, N. Y.

PROMOTION FROM ASSOCIATE

HEINEN, E. J., St. Paul, Minn.
JOHNSON, LESTER G., Schenectady, N. Y.
MAYHEW, RAY, Minneapolis, Minn.
PORTER, WILL R., Princes Bay, S. I.

PROMOTION FROM JUNIOR

AULL, JEROME J., Cincinnati, Ohio
BAUSCH, CARL L., Rochester, N. Y.
BEAN, IRVING McC., Milwaukee, Wis.
BOYER, FREDERIC Q., New Haven, Conn.
BURGESS, A. BRADLEY, Worcester, Mass.
DEAN, ARTHUR, Flushing, N. Y.
DU MOULIN, WALTER L., Morenci, Ariz.
FARRINGTON, THOMAS H., Owego, N. Y.
FAULKNER, DAVID S., New York, N. Y.
GARDNER, HENRY, New York, N. Y.
GLADFELTER, HERBERT S., Memphis, Tenn.
HALLADAY, HARRY F., Watertown, N. Y.
HARTWELL, ARTHUR E., Houston, Texas
LEE, NIXON, St. George, S. I.
NORELIUS, EMIL F., Peoria, Ill.
PARSONS, EDMUND S., Ilion, N. Y.
PIGOTT, REGINALD, J. S., New York, N. Y.
ROWLEY, FRANK B., Minneapolis, Minn.
ULBRICHT, TOMLINSON C., Havana, Cuba
VERNER, WM. F., Ann Arbor, Mich.

SUMMARY

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THIRD INTERNATIONAL CONGRESS OF REFRIGERATION

In response to the invitation of the American Society of Refrigerating Engineers and of The American Society of Mechanical Engineers, extended at the Vienna Congress of 1910, the Third International Congress of Refrigeration was held in this

country from September 15 to 24. As most of the delegates from foreign countries arrived in New York, The American Society of Mechanical Engineers extended the use of its rooms during the week ending September 14, and arranged a number of events for their entertainment.

The delegates were received in Washington on September 15 at the formal opening session of the Congress, leaving on September 16 for Chicago, where the professional sessions were held. Part of each day was devoted to sightseeing and inspection of points of technical interest. On Sunday, September 21, there was a steamship excursion to Milwaukee, and on Tuesday evening, September 23, a grand banquet, complimentary to the foreign delegates, at which no foods or beverages were served except those preserved by refrigeration under the usual conditions and for the length of time customary in American commercial practice. The Congress was formally closed at the session of September 24, many of the delegates participating, however, in the extended excursions to St. Louis, San Francisco and Panama which had been arranged to follow the meetings.

The engineering activities of the Congress covered phenomena ranging in temperature from the lowest nearly to the highest obtainable with our present means, from within two degrees of the absolute zero to a heat at which iron will melt like butter on a range. From the laboratory of Professor Kamerlingh-Onnes of Leyden were reported experiments made at the temperature of liquid hydrogen and liquid helium, by means of which it was proved that radio-activity is not affected even by the lowest temperature; deviations from Curie's law become sensible at low temperatures, and, for example, oxygen which at higher temperatures in the gaseous state follows the law of Curie, deviates from this law when at low temperatures it has passed into the liquid or the solid state. Metals at very low temperatures lose nearly all of their electric resistance, and become what the investigators call superconductors. It is proposed to utilize this property of the metals for the construction of especially powerful magnets, at first for research purposes. Professor Becquerel reported on his work on the optic and magneto phenomenon and the Hall effect at very low temperatures, this phenomenon giving a clearer insight into the mystery of the structure of matter than could hitherto be obtained. Mr. Gardner T. Voorhees described his experiments with the liquefaction and solidification

of carbon dioxide, and phenomena observed during these processes through special windows in the CO_2 apparatus, which led him to believe that there is an intermediate state of matter on the borderland between gases and liquids. Mr. George Claude gave an illustrated lecture on the liquefaction of air, its properties, and the rare gases obtained as by-products. Liquefaction of air may be used for the production of oxygen, for welding and cutting of metals, for example. It appears, however, that it may also be used for the production of tremendously powerful explosives: carbon immersed in liquid oxygen, and set on fire in open air, burns slowly, but the same material confined in a cartridge and acted on by a fulminate, explodes with the violence of dynamite.

Dr. F. Linde gave an illustrated description of his system of production of hydrogen from water gas by liquefying, by means of liquid nitrogen, the gases in mixture with hydrogen, liquid nitrogen, and when desirable, liquid oxygen also, being obtained as by-products. Tengbeck and Altenkirch described their system of heating and refrigeration by means of resorption refrigerating machines with ice and cold obtained as by-products.

As was to be expected, the problem of transportation of perishable goods in all of its aspects, legal, mechanical, and economic, attracted considerable attention at the Congress. The questions of icing of trains at loading station and in transit, the use of combination heated and refrigerated cars, the transportation of perishable goods from car to steamer by barges in large ports, meat forwarding from distant lands by steamers, fish transportation on special cold storage steamers in such widely scattered places as Central Asia and the Amazon river, all were fully described and discussed. The cold storage of goods was likewise carefully gone into, several papers being devoted to the various questions of cold storage plant administration, relations with the depositors, thickness of insulation to be used, etc.

Attention may be called here to several points powerfully impressed upon the minds of the members, even though they did not form the object of any particular paper. The foremost among them is the remarkably high level on which the technical methods of the refrigerating industry are maintained, especially that branch of it which has to deal with the lowest range of temperature. It is a fact well worth noticing that precisely the

industries which, it appeared only a few years ago, had no commercial chances owing to the prohibitively high cost of manufacture, have since become models of cheap and efficient production. The counter-current principle, utilization of by-products, elimination of heat and cold losses through efficient insulation, and high perfection of design in which every detail is fully thought out, have been in these plants carried out to such an extent that, for example, in the Linde process of manufacture of hydrogen from water gas, the final product, hydrogen, costs somewhat less than the water gas from which it is manufactured, plus depreciation of machinery, the entire cost of manufacture being covered by the cost of by-products recovered, and the day is not far off when the result will be still more favorable. In the Claude process of air liquefaction, the amount of air evaporated to obtain the separation of nitrogen from oxygen is replaced by a nearly similar amount of aid liquefied by that very evaporation, so that after the first batch of liquid air is manufactured, very little additional power is required to carry on the manufacture indefinitely; in the Altenkirch heating system ice is obtained as a by-product, etc. All this shows very clearly what great advantages an industry may derive from having developed along strictly scientific lines, and with a full knowledge at every step of its development of all the losses, technical or economic, incurred in each one of its operations.

In this connection may be mentioned the preponderance of the teaching staff of the technical school in the development of the mechanical side of the refrigerating industry, as illustrated at the Third Congress. The names of Linde, Lorenz, d'Arsonval, Kamerlingh-Onnes, Monteil, were prominent at the Congress both in connection with many technical applications in the industry, and as teachers and discoverers of those laws of thermodynamics to the knowledge of which is due the surprisingly rapid and extensive development of the art of refrigeration in the last few years.

Another important feature of the Congress was the developing of confidence among the people generally in food which has been preserved by refrigeration, and the appreciation of the service which the art of refrigeration renders to mankind by virtue of its ability to conserve all perishable products, making them available out of season, and producing greater uniformity in prices. With the increasing congestion of humanity in the

cities, and the necessity of securing a food supply at great distances from their source, refrigeration cars and ships are now an absolute necessity for the preservation of these perishable products. A comprehensive exposition was held of the latest machinery for the manufacture of various kinds of ice and refrigeration, and of the meats, fish and vegetables themselves which had been kept frozen for periods upward of a year without any change of quality.

The Congress was under the patronage of the President of the United States and of the Secretary of the Department of Agriculture. It was attended by nearly 1000 delegates and may be considered one of the most successful of its kind.

A NEW PROCESS OF CLEANING PRODUCER GAS

By H. F. Smith

ABSTRACT OF PAPER

The gas to be cleaned is first cooled sufficiently to condense the tar vapors and is then passed under pressure through a porous diaphragm of spun glass. Both gas and tar pass through the diaphragm, but in passing the diaphragm the tar particles coalesce into large drops which cannot be carried along with the gas current. Any desired degree of gas cleanness can be secured. Water or other washing fluid is not required. The process is not one of filtration. A theory is advanced to explain the observed results.

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A NEW PROCESS OF CLEANING PRODUCER GAS

By H. F. Smith, Lexington, Ohio

Member of the Society

In 1902 the writer instituted a series of investigations to determine the nature of the mechanical impurities present in producer gas from bituminous coal with a view to devising more effective methods for their removal. These investigations have since been continued and have resulted in the development of a commercial apparatus involving some new and interesting principles.

2 The tar and other mechanical impurities present in raw bituminous producer gas are in an extreme state of subdivision. The number of particles present is so great and the quantity of gas to be handled in commercial plants so large that the problem presents more than ordinary difficulties. The effectiveness of the ordinary types of mechanical gas washers and purifiers leaves much to be desired. The primary object has accordingly been to produce equipment that will be capable of yielding gas of a higher degree of cleanness than obtainable by ordinary methods. The apparatus in its present stage of development can be readily understood from Fig. 1.

3 The raw producer gas on leaving the producer is first cooled to a point where the tar vapors are condensed by being passed through a primary cooler or condenser. From this the gas is carried into an ordinary rotary gas pump B which delivers the gas under pressure into the main C; it is then delivered through a porous diaphragm E and discharged from there into the main F. A sump or separator G is provided in which the tar accumulates.

4 The structure of the diaphragm E is a matter of considerable importance for the successful carrying out of this process

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and the materials used seem to have an important bearing on the operation of the equipment. The diaphragm must be sufficiently porous to permit the gas and tar to pass freely, otherwise it will soon become blocked with deposits from the gas and fail to operate. Many materials may be used for this purpose, but at present spun glass is preferred. The glass fibers are not only entirely unaltered by chemical action but seem to possess

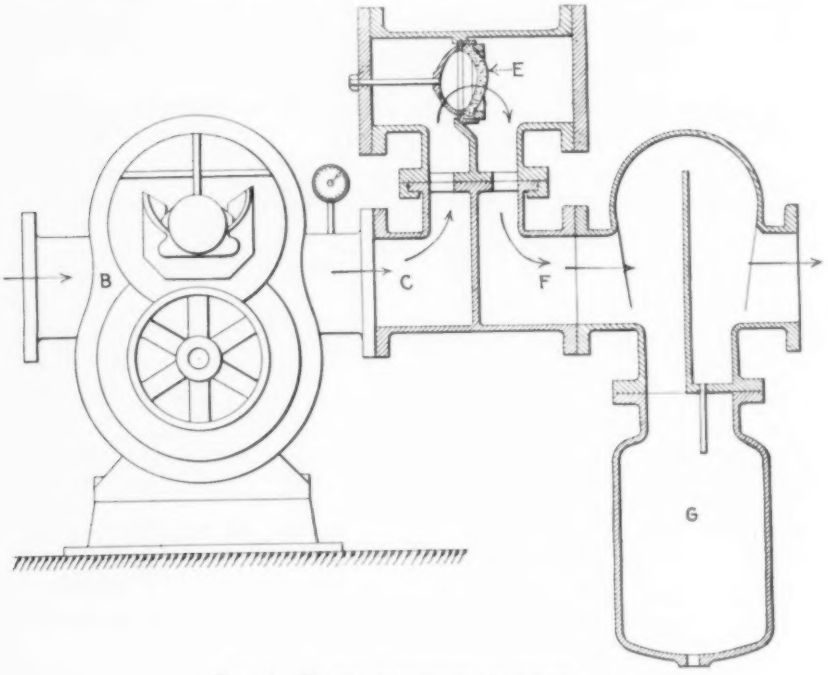

FIG. 1 STATIC SCRUBBER LAYOUT

the necessary physical properties for the successful carrying on of this process. The spun glass in the form of ordinary glass wool (which should be carefully distinguished from slag wool, as the latter is not practicable for this purpose) is built into the form of a uniform diaphragm and is retained between two metal screens. The density of the diaphragm can be regulated by the quantity of glass used and by the degree of compression maintained between the metal screens. Ordinarily, this diaphragm is made up to a thickness of approximately one-quarter of an inch. The diameter of the diaphragm must be adjusted in accordance with the quantity of gas to be treated. Ordinarily, about 400 cu. ft. per hr. can be handled for each square inch

of diaphragm area. No tar is retained in the diaphragm, both tar and gas being discharged together.

5 In passing the diaphragm an important change in the physical state of the tar occurs. On the entering side the tar exists in a large number of minute particles, ordinarily known as tar fog. In passing the diaphragm these particles are caused to coalesce so that on the discharge side the tar particles are of relatively large dimensions, so large in fact that they can no longer be carried forward in the gas current and immediately separate out by gravity. All that is necessary for the complete separation of the tar from the gas is to provide a sump, or drip, into which the precipitated tar can drain.

6 It appears to be possible to secure almost any desired degree of gas cleanness simply by regulating the pressure maintained across the diaphragm. In ordinary commercial operation, it is found that a difference in pressure of from 2½ to 4 lb. will give a degree of gas cleanness that is ample for any commercial requirement. Thirty cubic feet of gas cleaned in this way can be passed through a white filter paper without producing any discoloration.

7 The distinction between this process and the process of purification by filtration can be best shown by outlining the conditions essential for each process:

a In filtration the best separation is secured when the rate at which the materials to be separated pass the filtering medium is slow. One of the substances to be separated remains in the filter.

b In the process in question good results can be secured only when the velocity of the gas passing through the diaphragm is very high. Nothing whatever remains in the diaphragm.

8 At low velocities the gas will pass through the porous diaphragm used in this apparatus without any apparent alteration, and the degree of effectiveness of cleaning is directly related to the velocity of flow. For example, the degree of cleanness produced with the velocity of flow resulting from 5 lb. pressure is very much greater than the degree of cleanness produced by the velocity of flow resulting from 1 lb. pressure, and when the velocities are as low as those produced by a pressure of a few ounces only, there is no perceptible change in the tar content of the gas after passing through the diaphragm.

9 No water is used in connection with this process except

that required to cool the gas. As a consequence there is no production of tar emulsion and the water flows from the condenser perfectly clear. The tar separated by this process is practically water free, and can accordingly be used for any purpose to which coal tar is adaptable. One sample of tar drawn directly from the receiver showed on distillation a water content of less than 1 per cent as compared with from 20 to 60 per cent which is ordinarily present in gas producer tar from mechanical washers. The calorific value of producer tar from Hocking coal is approximately 15,800 B.t.u. per lb., about 140,000 B.t.u. per gal.

10 For the maintenance of continuous operation the tar must be sufficiently fluid to pass through the porous diaphragm without creating undue resistance, and therefore it is necessary to maintain the temperature of the gas entering the diaphragm at a point that will reduce the viscosity of the tar to as low a point as is consistent with complete condensation of the tar vapors.

11 It is also apparent that this apparatus would not be well suited to use on gas containing large quantities of lamp black or for the purification of gas from coals yielding very heavy viscous tars. For high volatile coals, however, such as are found in Ohio, Indiana and Illinois, and for lignite, it has been found in practice to be thoroughly practical and effective. It is possible that further developments may extend the applicability of this method to conditions which are not now considered practical.

12 The exact method by which this tar extractor operates has not been conclusively demonstrated. Two theories have been advanced which may possibly cover the ground: The first and most obvious is that the tar particles are precipitated by being brought into direct collision with the threads or filaments of the porous diaphragm.

13 That this does not constitute a complete explanation of the process is indicated by the fact that the material of which the porous diaphragm is constructed has a marked bearing on the effectiveness of the process and would indicate some action other than simple mechanical collision. For example, if the porous diaphragm is made up of steel wool instead of glass wool (the physical structure of the diaphragm being as nearly as possible the same in each case) the process does not operate with anything like the effectiveness secured with glass diaphragms. It would seem that the possibility for collision would be the same in both cases.

14 A phenomenon, first observed by the writer in 1902 during some experimental investigations, gives further credence to the theory that there is some action other than pure mechanical collision. If the gas is caused to pass through a small tube with perfectly smooth walls, as for example a tube of glass, no particular precipitation of tar occurs as long as the velocities of travel are slow. However, as the velocities increase to a point where there is considerable friction between the gas and the surface of the containing tube a heavy precipitation of tar occurs on the surface of the glass. This fact leads to the conclusion that friction is in some way concerned in this process, since the probability of mechanical collision is rather remote. Since friction between rapidly moving gases and enclosing tubes is known to be productive of electrical phenomena, it was assumed that this might possibly have some bearing on the action of this process. In fact this interpretation was the one first placed upon the phenomenon observed in 1902 and an effort was made to work out a tar extractor along this line.

15 An experimental apparatus was constructed at that time in which heavily charged electrodes were employed to precipitate the tar particles and it was found that fairly effective results could be secured. Experiments along this line continued for a number of years, but the difficulties in the way of producing commercially practical apparatus caused its final abandonment. The rate at which the tar particles could be moved through the gas under the influence of moderate potential gradients was very slow. It was accordingly necessary to use exceedingly high potentials in order to secure effective results. With the spacing of electrodes of approximately 1½ in. a potential difference of 25,000 to 35,000 volts was required for effective precipitation. On account of the difficulty of maintaining proper insulation under these potentials and on account of the great danger of serious injury to an unskilled operator in manipulating apparatus of this kind, this method was not considered practical. It was noted, however, that by decreasing the distance between the electrodes a very marked decrease in potential was observed. Accordingly another experiment was devised which will perhaps throw still further light on the method of operation of the process under consideration.

16 A series of electrodes was prepared with exceedingly small intervening spaces, and placed in connection with a source

of direct electro motive force, the potential difference between the plates being much below that required to produce any ionizing discharge. It was found that at these small distances distinct cleaning effects could be obtained without ionization. Maintenance of the electric charge from external sources was troublesome owing to electrolytic short circuits occurring between the electrodes through deposits of tar and moisture from the gas. The fact, however, that there is a distinct attraction exerted by electrified plates at comparatively low potentials (which is sufficient to cause a precipitation of tar particles from gases) leads to the conclusion that if the distance between the electrodes could be reduced sufficiently the potential differences required for effective electrical action would be very small.

17 It would seem possible, therefore, that in addition to the effects of mechanical collision there might be a distinct electrical attraction exerted by the glass fibers constituting the porous diaphragm which are located at microscopic distances from each other and which are undoubtedly subjected to some electrification from friction with the gas currents. If the possibility of such electrical action is considered, the increased effectiveness of glass as compared with steel for the construction of the porous diaphragm is satisfactorily explained. That friction of this nature is capable of producing electrical disturbances of considerable magnitude is well established.

18 It might be interesting in this connection to refer to recent experimental determinations by Professor Dolezalek of Charlottenberg, Germany, who showed that the friction of liquid benzol against the sides of containing pipes may set up potential differences of as much as 3000 volts. As a very small fraction of this potential would be sufficient to account for the observed effects, it would seem only reasonable to presume that in addition to the effects of mechanical collision which undoubtedly exist, there is some electrical action which is of material aid in causing the coalescence of the particles of tar fog.

19 Whatever may be the correct explanation of the phenomenon, its effectiveness and practical importance are beyond question. The first commercial equipment of this kind has now been in continuous operation for approximately 18 months. This outfit is handling gas for a producer gas power plant of approximately 1000 h.p. capacity. The second commercial equipment is handling approximately 900 h.p. producer gas, and has

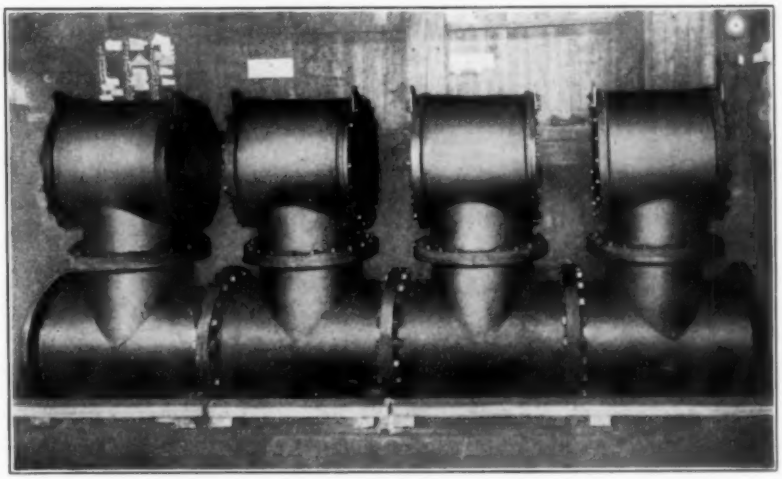

FIG. 2 SMITH TYPE F TAR EXTRACTOR. CAPACITY 250,000 CU. FT. PER HOUR

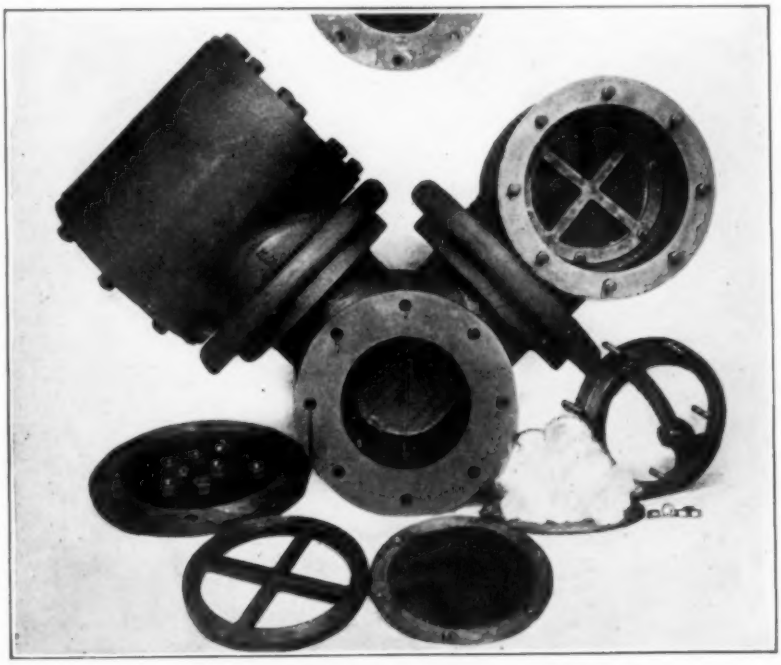

FIG. 3 VIEW SHOWING VARIOUS PARTS OF COMMERCIAL EXTRACTOR

been in daily service for approximately ten months. The largest single installation is an equipment for cleaning 200,000 cu. ft. of gas per hour. An idea of the dimensions and form of this equipment can be obtained from Figs. 2 and 3. This installation is operated in connection with a single producer unit which is of interest because it is one of the largest single unit plants ever installed in this country. This producer has an effective grate surface of 250 sq. ft. and is rated to gasify 3000 lb. of Illinois bituminous coal per hour.

EXTINGUISHING FIRES IN OILS AND VOLATILE LIQUIDS

By Edw. A. Barrier

ABSTRACT OF PAPER

The subject of the extinguishing of fires in such liquids as gasolene, lubricating oils, acetone, alcohol, ether, etc., is discussed; special reference is made to the new extinguishing agents for this class of materials: carbon tetrachloride, sawdust and bicarbonate of soda, and frothy mixtures. The properties of these extinguishing agents, the conditions under which they are the most efficient, and their limitations, are considered.

EXTINGUISHING OF FIRES IN OILS AND VOLATILE LIQUIDS

EDW. A. BARRIER,[1] BOSTON, MASS.

Non-Member

The extinguishing of fires in oils and in most of the volatile liquids has always been a difficult problem and where fires of this kind occur the results are frequently very disastrous. Our most common extinguishing agent, water, works rather unsatisfactorily upon the majority of such fires, but it is still the only one available where heroic measures are required. Comparatively recently, however, there have been two or three other materials introduced for use as extinguishers which have shown some promise for dealing with these fires, and it is the purpose of this paper to discuss these materials and the conditions under which they prove the most efficient.

2 Not all fires in volatile liquids are difficult to handle with water. When the liquid is miscible with water this extinguishing agent can be successfully used. Examples of this kind are denatured alcohol, wood alcohol, grain alcohol, acetone, etc. Where the liquid is not miscible with water little or no effect is produced except to wash the burning liquid out of the building where it may be completely consumed or, if the quantity of oil is small, possibly to extinguish the fire by the brute cooling effect of a large quantity of water sprayed upon the fire. Soda and acid extinguishers are somewhat more effective than pure water, but even they fail under most conditions. The various grenades containing salt solutions which were formerly extensively exploited are of course practically worthless.

3 The only principles that can be made use of in extinguishing fires in volatile oils are, (*a*) to form a blanket either of gas

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or of solid material over the burning liquid which will exclude the oxygen of the air, or, (*b*) to dilute the burning liquid with a non-inflammable extinguishing agent which is miscible with it.

SAWDUST AND BICARBONATE OF SODA

4 To the blanketing type of extinguishers belongs sawdust. Paradoxical as it may seem, ordinary sawdust is an excellent extinguishing agent for certain volatile liquids, especially those of a viscous nature. A considerable number of experiments were conducted in the fall of 1912 by the inspection department of the Associated Factory Mutual Fire Insurance Companies, in the extinguishing of fires in lacquer and gasolene in tanks with sawdust, and the results were surprisingly satisfactory.

5 The liquids were placed in three tanks 30 in. long, 12 in. wide and 16 in. deep; 48 in. long, 14 in. wide and 16 in. deep; and 60 in. long, 30 in. wide and 16 in. deep. The sawdust was applied with a long-handled, light but substantially built snow shovel having a blade of considerable area. In every case the fires were extinguished readily, especially in the two smaller tanks which were about as large as any ordinarily employed for lacquer in manufacturing establishments.

6 The efficiency of the sawdust is undoubtedly due to its blanketing action in floating for a time upon the surface of the liquid and excluding the oxygen of the air. Its efficiency is greater on viscous liquids than on thin liquids, since it floats more readily on the former than on the latter. The sawdust itself is not easily ignited and when it does become ignited it burns without flame. The burning embers have not a sufficiently high temperature to reignite the liquid.

7 The character of the sawdust, whether from soft wood or hard wood, appears to be of little or no importance, and the amount of moisture contained in it is apparently not a factor, so that the drying out of sawdust when kept in manufacturing establishments for a time would not effect the efficiency.

8 It was found that the admixture of sodium bicarbonate greatly increased the efficiency of the sawdust as shown both by the shortened time and the decreased amount of material necessary to extinguish the fires. A further advantage of the addition of bicarbonate of soda is that it decreases the possible danger resulting from the presence of sawdust in manufacturing plants since it would be difficult, if not impossible, to ignite

the mixture by a carelessly thrown match or any other ready source of ignition.

9 Although the efficiency of the sawdust is greatest on viscous liquids such as lacquers, heavy oils, Japan, waxes, etc., in the tests referred to, fires were extinguished in gasolene contained in the smallest tank and also when spread upon the ground. In larger tanks the sawdust or bicarbonate mixture does not work so well since the sawdust sinks before the whole surface can be covered, whereupon the exposed liquid reignites.

CARBON TETRACHLORIDE

10 In recent years carbon tetrachloride has received considerable attention as a fire-extinguishing agent. This is due largely to the activity of certain manufacturers of fire extinguishers which use liquids, the basis of which is carbon tetrachloride.

11 This substance is a water white liquid and possesses when pure a rather agreeable odor somewhat similar to chloroform. A considerable proportion of the commercial article upon the market, however, contains sulphur impurities which impart a disagreeable odor to the liquid. The substance is quite heavy, its specific gravity being 1.632 at 32 deg. fahr. It is non-inflammable, non-explosive, and is readily miscible with oils, waxes, japan, etc. When mixed with inflammable liquids it renders them non-inflammable provided a sufficient quantity is added. Its vapor is heavy, the specific gravity being about five and one-half times that of air, consequently it settles very rapidly. As an extinguishing agent it operates by both the principles mentioned in Par. 3, namely, it dilutes the inflammable liquid rendering it non-inflammable, or at least less inflammable, and it forms a blanket of gas or vapor over the burning liquid which excludes the oxygen of the air.

12 Although this paper is confined to a discussion of extinguishing fires in oils and volatile liquids, it may not be out of place to mention that the claims made by certain manufacturers producing extinguishers which use liquids, the basis of which is carbon tetrachloride, are grossly exaggerated. These preparations, none of which is more efficient than carbon tetrachloride, are not the equivalent of the ordinary water extinguishers for general use on such materials as cotton, wood, paper, oily waste, etc.

13 On volatile liquids, oils, etc., carbon tetrachloride has, however, shown very satisfactory results under some conditions, but the readiness with which a fire can be extinguished with it depends to a considerable extent upon the skill of the operator and the nature of the fire. In tank fires the length of time that the liquid has been burning is an important factor, and in such cases where the sides of the tank become heated the only way in which the fire can be extinguished is to squirt the liquid forcibly at the sides. If the carbon tetrachloride is squirted directly into the liquid it is much more difficult, if not impossible, to extinguish the fire.

14 The height of the liquid in the tank is also a very important factor. Where the liquid is low the sides form a pocket which retains the vapor and aids considerably in smothering the blaze. When the tank is nearly full, however, this condition does not exist, and it is then very difficult, if not impossible, to extinguish a fire in a highly volatile liquid, such as gasolene; only the most skilled operators are successful in these cases. The size of the tank or the extent of the fire if upon the floor is, as would be expected, of considerable importance. In tanks larger than about 28 in. by 12 in. more than one extinguisher and operator working at a time are necessary to extinguish a fire in such materials as gasolene. In one test where a tank 60 in. by 30 in. was used no less than seven operators were necessary, and even then it was only with the greatest difficulty that the fire was put out.

15 All of the above remarks apply to carbon tetrachloride in the ordinary one-quart extinguisher as generally sold. It is probable that a large extinguisher which could throw a large stream would prove more efficient, but on account of the great weight of carbon tetrachloride such an extinguisher would have to be specially designed to make it readily portable by mounting on a truck or some similar means. Expelling the liquid by means of a hand-pumping arrangement would probably be unsatisfactory, and it would therefore be necessary to force it out in some other way.

16 A few systems have recently been installed in which an elevated tank containing carbon tetrachloride was connected with automatic sprinklers or perforated pipes located in hazardous rooms where volatile and inflammable liquids are in use. So far as is known none of these systems have as yet been called

upon to extinguish a fire, but there appears to be no reason why such a system should not provide excellent protection in special cases. In such systems it would be necessary to consider the safety of the workmen and furnish ready means of escape, since carbon tetrachloride is an anesthetic and where thoroughly sprayed through the air as from an automatic sprinkler it would probably produce rapid results.

17 The nature and effect of the fumes given off when carbon tetrachloride is thrown upon a fire is a subject which has received a great deal of discussion. When the liquid comes in contact with a fire the vapor is partly decomposed resulting in the evolution of a considerable quantity of black smoke which is undoubtedly finely divided carbon. Pungent gases are also produced which appear to be mostly hydrochloric acid with possibly a small amount of chlorine. Since carbon tetrachloride contains no hydrogen from which hydrochloric acid could be formed this substance must be produced by the action of chlorine on the gases arising from the burning material or upon the moisture of the air.

18 The fumes of carbon tetrachloride although of a very pungent nature do not produce any permanent injury under ordinary conditions where the operator can make his escape after he has inhaled all that he can stand, but they are a distinct handicap in fighting a fire and are one of the objectionable features to carbon tetrachloride as a general fire extinguishing agent. In large rooms or where a small quatity of carbon tetrachloride is sufficient to extinguish a fire the gases are of course less objectionable.

FROTHY MIXTURES

19 Another method of extinguishing fires in oils and volatile liquids which has recently been proposed and experimented with is that of using frothy mixtures. The idea seems like a very promising one and the tests which have been thus far reported indicate very satisfactory results. The idea was originated and has been developed in Germany. So far as is known no experiments have been conducted in this country.

20 The process consists essentially in causing two liquids to mix in a tank where foam is produced. The tank is made airtight and sufficiently strong to permit of the foam being forced out by carbon dioxide under pressure, and the foam is conveyed

to the fire by means of a line of hose. The exact nature of the liquids has not been disclosed, but one of them probably consists of a sodium carbonate solution containing froth-forming ingredients such as glue or casein and the other an alum solution. The two on coming together generate carbon dioxide which produces froth. This froth is reported to be quite stiff and to shrink in volume but a comparatively small amount even after a period of half an hour.

21 A number of tests were conducted in the winter of 1912 in Germany; some of them on a considerable scale. In one case as much as 5 tons of crude naphtha in a tank was involved, and in another an area of 1300 sq. ft. of burning tar was used. In all cases the results were reported satisfactory, the fires being extinguished in a short time.

22 The frothy mixture undoubtedly owes its efficiency to its blanketing action in settling upon the surface of the burning liquid, thus excluding the oxygen of the air, and to the fact that the bubbles of liquid contain carbon dioxide which upon bursting produce an atmosphere in which combustion cannot take place.

23 According to the latest reports the matter is still in an experimental stage, various details regarding the form of apparatus, most efficient pressure, and design of nozzles being under consideration; but from what has already been done it would appear that the idea is a very promising one, and that this method of extinguishing fires in oils and volatile liquids will prove to be by far the most efficient of any that has as yet been suggested.

THE PROPERTIES OF STEAM

By R. C. H. Heck

ABSTRACT OF PAPER

This paper offers a new pair of characteristic equations for steam, which give specific volume and heat content (total heat) respectively in terms of pressure and temperature as independent variables. These equations must be and are connected by certain mathematical relations from thermodynamic theory; and at saturation they are in very close agreement through Clapeyron's equation.

Especial emphasis is laid upon the shape of isothermal curves in plots of the pressure-volume product and of heat content on pressure as base. Heretofore, the data for such curves have been volumetric only. Now a new determinant is introduced, in an application of throttling data which gives a very good layout of the total-heat isothermals.

The several lines of experimental determination have been volume measurement, total heat of saturated steam, specific heat of superheated steam, and rate of change of temperature with pressure in throttling (during which total heat remains constant). Bringing the last fully into the problem doubles the field of experimental influence upon the form of the characteristic equations, and greatly extends the range of conditions over which at least some data are now available.

An important feature of the paper, little more than suggested in the following abstract, is the group of graphical comparisons with the physical data and with other formulations: these others are, the tables or formulas of Marks and Davis, of Mollier (Callendar), of Linde, and of Goodenough. The last are used as published by the Society in Volume 34, Page 507 of Transactions.

Because the equations here presented are a little more than usually complicated in the form of the terms which show the departure of steam from an ideal "perfect" gas, numerical values of the several factors have been worked out for every 10 deg. up to 1000 deg. fahr. and at suitable pressure intervals up to 1000 lb. per sq. in. Beside this table for superheated steam (in the complete paper) there is also a table for saturated steam with temperature as argument and the same range and spacing.

THE PROPERTIES OF STEAM [1]

By R. C. H. Heck, New Brunswick, N. J.

Member of the Society

The fundamental physical properties of steam are pressure p, temperature t, specific volume v, and heat content or total heat h. Of these, p and t are taken as independent variables, and equations expressing v and h in terms of them are developed. From these the values of internal energy, entropy, specific heat, etc., can be calculated.

2 Two relations from thermodynamic theory find useful application in connecting volume and heat formulae, namely

$$\left(\frac{dc_p}{dp}\right)_t = -AT\left(\frac{d^2v}{dt^2}\right)_p \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

and

$$\left(\frac{dh}{dp}\right)_t = -A\left[T\left(\frac{dv}{dt}\right)_p - v\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

And at saturation, where p and t cease to be independent of each other, there must be satisfaction of Clapeyron's equation

$$\frac{r}{u} = AT\frac{dp}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

where r is latent heat and u is the increase of volume from water to steam during vaporization.

3 The two general equations developed in the paper are as follows:

a Volume Equation

$$pv = BT - yp - zp^{2.4} \quad \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

B is the gas constant for H_2O, determined by molecular weight and taken as 0.5956, for units as defined in Par. 4.

[1] This paper is published in abstract only. The complete form is on file and may be referred to in the rooms of the Society.

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$$y=\frac{[4.66365]}{(t+130)^2} \quad \text{.....[5a]}$$

$$z=\frac{[11.02244]}{(t+40)^6} \quad \text{.....[5b]}$$

b Heat Equation

$$h = h_o - y'p - z'p^{3.4} \quad \text{.....[6]}$$

$$y'=\frac{[4.40815]}{(t+130)^2}+\frac{[6.75057]}{(t+130)^3} \quad \text{.....[6a]}$$

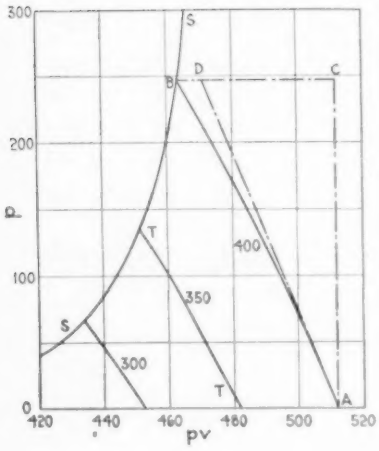

FIG. 1 ISOTHERMALS OF pv ON p

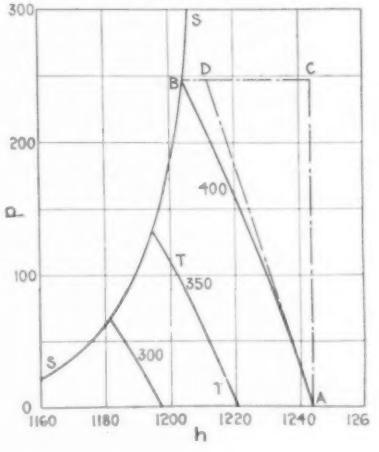

FIG. 2 ISOTHERMALS OF h ON p

$$z'=\frac{[10.75471]}{(t+40)^6}+\frac{[13.31101]}{(t+40)^7} \quad \text{.....[6b]}$$

h_o is the total heat at zero pressure given by the formula

$$h_o = 309.64 + 0.3020\,t + [2.42163]\log(t+688) + 0.000072\,t^2 \quad \text{..[7]}$$

4 These equations are for English units, with p in pounds per square inch absolute, t or $T=(t+459.64)$ in degrees fahrenheit, v in cubic feet per pound of steam, and heat quantities in the mean British thermal unit. In the paper all formulae are also converted to metric-centigrade units. One special notation adopted is the giving of the logarithm of a constant, thus [4.66365] in equation [5a], in place of the number itself.

5 Equations [5] and [6] are illustrated directly by Figs. 1 to 4, their derivatives by Figs. 5 and 6. Instead of the volume v, which varies so widely with pressure, the product pv is plotted in every case. These three pairs of companion diagrams show the close

analogies in behavior between external energy pv and heat content h. In Figs. 1 to 6 curve SS is the saturation line, the lower limit of the field covered by the general equations.

6 In Figs. 1 and 2, strong emphasis is laid on the isothermal

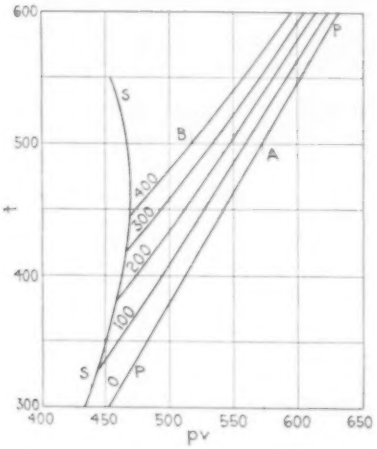

FIG. 3 EXPANSION AT CONSTANT PRESSURE

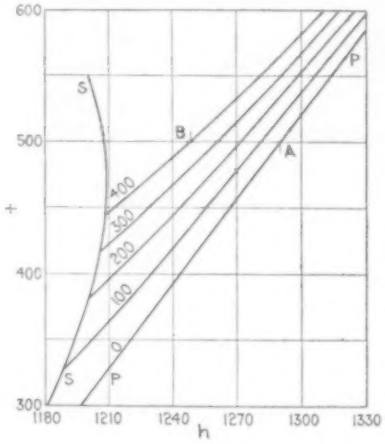

FIG. 4 HEATING AT CONSTANT PRESSURE

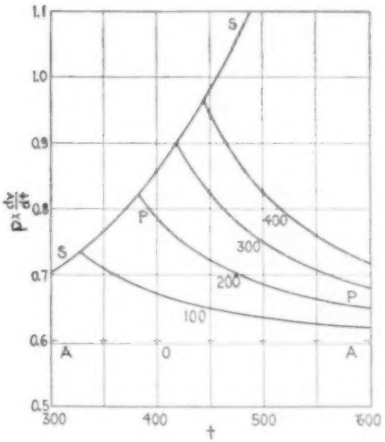

FIG. 5 RATES OF EXPANSION

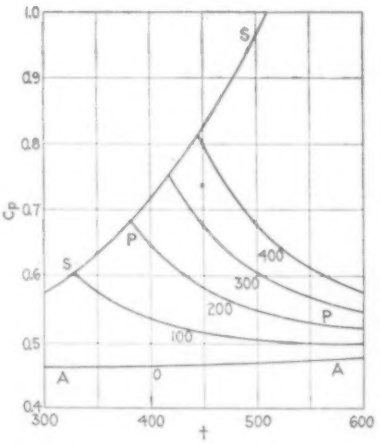

FIG. 6 CURVES OF SPECIFIC HEAT

curves TT. For a perfect gas, pv or h would be constant with temperature, or either isothermal would be a vertical line like AC. Actually, and especially toward saturation, there is a shrinkage: the straight line AD shows the effect of term yp or $y'p$, while $zp^{2.4}$ or $z'p^{2.4}$ adds curvature to the isothermal.

7 Change under constant pressure is shown in Figs. 3 and 4,

where each curve of type PP is marked with the value of its uniform pressure in pounds absolute. In Fig. 3, the line for zero pressure represents the straight-line variation of ideal pv (or BT) with temperature; and any distance like AB shows the shrinkage from ideal to actual, along the isothermal and with rise of pressure. In Fig. 4, the line for zero pressure is not straight because the specific heat is not constant but rises slowly with the temperature.

8 Figs. 5 and 6 show rates of change under constant pressure, still retaining the factor p with v. The derivatives from equations [5] and [6] are, for Fig. 5

$$p\left(\frac{dv}{dt}\right)_p = B - p\frac{dv}{dt} - p^{2.4}\frac{dz}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

for Fig. 6

$$c_p = c_{po} - p\frac{dy'}{dt} - p^{2.4}\frac{dz'}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

The y and z derivatives are negative so that the secondary terms add themselves to the first, principal term, and the curves are higher as the pressure is greater.

USE OF THROTTLING DATA AND RELATIONS

9 Heretofore, all determination of the shape of the isothermals in Figs. 1 and 2 has been by volume data. The paper introduces a new determinant on the side of heat content, based upon throttling data. The operation of throttling is one in which the pressure and temperature fall while the heat content remains unchanged. In Fig. 7 the three important groups of throttling experiments on record are plotted together, in comparison with curves of uniform total heat from equation [6]. Here, on p as base and with t as ordinate, are h-constant curves and t-constant horizontal lines. In Fig. 2, taking vertical p as base and h as ordinate, there are t-constant curves and h-constant vertical lines. Evidently, the slope of the throttling curves in Fig. 7 must have a direct bearing upon the slope of the isothermal curves in Fig. 2.

10 The relation is established as follows: from the general statement $h = f(p, t)$, write the differential equation

$$dh = \left(\frac{dh}{dp}\right)_t dp + \left(\frac{dh}{dt}\right)_p dt \quad \ldots\ldots\ldots\ldots\ldots\ldots [10]$$

Now impose the condition $h =$ constant or $dh = 0$, and get for the rate of change of h with p when t is constant, or the slope from the vertical of the isothermal in Fig. 2, the value

$$\left(\frac{dh}{dp}\right)_t = -\left(\frac{dh}{dt}\right)_p \left(\frac{dt}{dp}\right)_h = -c_p \mu \ldots\ldots\ldots\ldots\ldots\ldots [11]$$

The specific heat c_p under constant pressure is, of course, the rate of change of heat with pressure for p constant, or $\left(\frac{dh}{dt}\right)_p$; and μ or

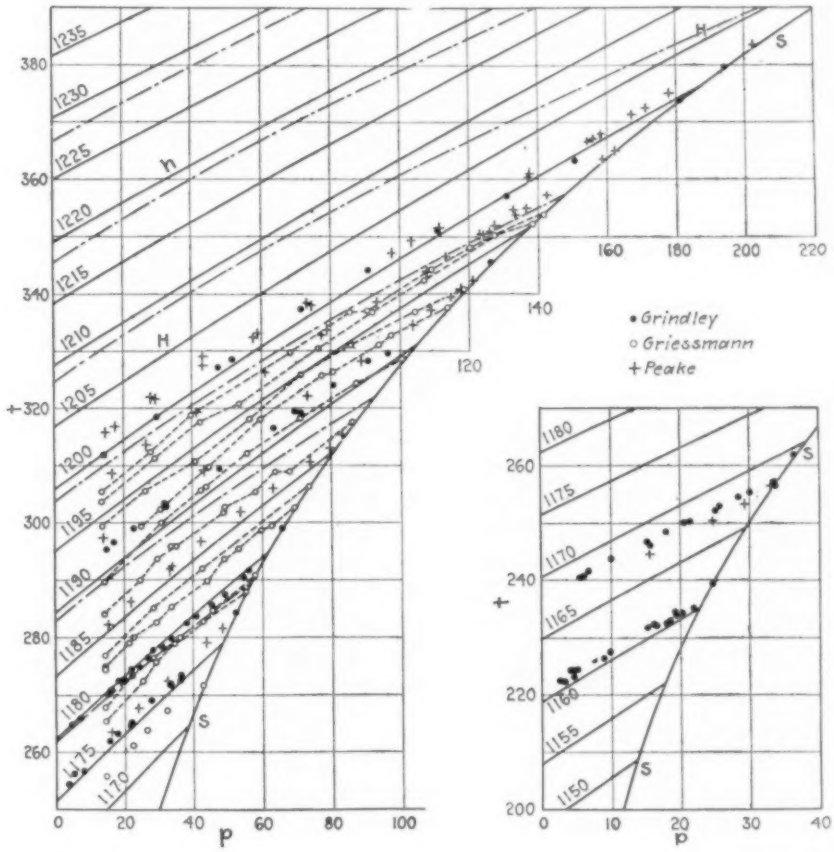

FIG. 7 THROTTLING EXPERIMENTS WITH STEAM INITIALLY SATURATED

$\left(\frac{dt}{dp}\right)_h$ is the throttling coefficient, the slope of the constant-heat curves in Fig. 7.

11 There is considerable experimental information concerning other gases as well as steam, which seems to indicate that μ is nearly or quite independent of p and h, being a function of t alone. If this

is true, any horizontal line of constant temperature in Fig. 7 will be crossed at the same angle by all the throttling curves which it intersects. And if these separate curves have all the same slant at any particular temperature, they may by horizontal shifting be brought into coincidence as one continuous curve.

12 The first step in an investigation along the line of these principles is to assume, for the time being, that μ is constant with t. A curve of μ on t has been laid out by H. N. Davis for the range from 250 deg. to 625 deg. fahr. With this as a start, to be modified by the reaction of trial calculations, a smooth curve of μ on t has been developed up to 1000 deg. and back to 32 deg. By numerical integration of $\frac{1}{\mu}$ or $\left(\frac{dp}{dt}\right)_h$, the general throttling curve is obtained with base t and an arbitrary pressure ordinate p'; that is, the scale of this p', in pounds per square inch, will be used for measuring differences of pressure, not absolute values.

13 Next it is necessary to get the specific heat c_{po} at zero pressure and from it the corresponding total heat h_o. The Knoblauch experiments are taken as authoritative, especially the later set. It is shown that a vertical h-constant line in a plot like Fig. 2 is cut at the same angle by all the isothermals crossing it, or that with p and h as coördinates the product $c_p\mu$ from equation [11] is constant along a line of uniform heat content. By means of this relation, it is easy to reduce the specific heat observations to zero pressure. Over high ranges of temperature, say from 500 to 1100 deg. fahr., the curve of c_{po} is thus very definitely determined. Toward the lower limit of the experiments (at about 300 deg.) there is poorer consistency, indicating probably that the validity of the method of reduction is weakened by approach to saturation. But there are other data in Fig. 7 and in the close experimental determination of total heat of saturated steam at low temperatures, which fix very definitely the mean value of c_{po} from 212 deg. to 32 deg. fahr. The curve as finally adopted has the equation

$$c_{po}=0.3020+\frac{[2.05941]}{t+688}+0.000144\,t \quad \ldots\ldots\ldots\ldots [12]$$

And with the proper constant of integration this leads to equation [7].

14 The method of determining the isothermal of heat content on pressure by means of the general throttling of constant-heat curve is illustrated in Figs. 8 and 9. Curve HH is a short portion of the constant-heat curve, p' on t. The particular problem taken is that of finding dimensions of the h-p isothermal for 500 deg. fahr., up to

300 lb. absolute pressure. In Fig. 8, this isothermal is the vertical line AB. From A measure down, to the scale of p', a series of 50 lb. intervals, and draw horizontal intercepts like CD. Then CD is the temperature gap (after a drop of 200 lb.) between a t-constant line AC and an h-constant line AD which have a common point at A. Now transfer these CD differences to Fig. 9, using the scale of temperature corresponding to successive values of h_0 wnich is laid off above the base line. The result is a series of points along the isothermal TT.

15 This scheme is complete in itself, but the data are by no

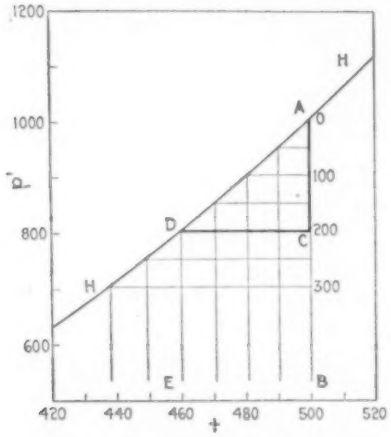

FIG. 8 USE OF THE THROTTLING CURVE

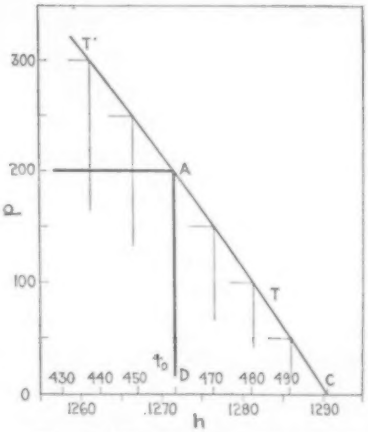

FIG. 9 DETERMINATION OF h-p ISOTHERMAL

means accurate enough to make it a complete determinant; nor can the hypothesis that μ depends upon t alone be accepted as rigorously correct. The method followed has been to obtain by this device a set of isothermals as in Fig. 2, and from them find approximate values of the functions y' and z' and the exponent of p in the last term of equation [6]. Then the task has been to cut and try and adjust constants until equations [5] and [6], tied together by relations [1] and [2], will satisfy, as nearly as possible, Clapeyron's equation at saturation.

16 One point remains to be considered before discussing the general equations. It is reasonable to assume that the simple law apparently making μ almost, if not wholly, a dependent upon t alone will have least modification by secondary influences when the pressure is low. From equations [6] and [11] for $p=0$ is obtained the particular relation

$$\left(\frac{dh}{dp}\right)_t = -y' = c_{po}\mu_o \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [13]$$

and the curve and tabular column of μ, as given in the paper, is really this μ_o, found after the form of y' had been determined partly by other considerations, through division of y' by c_{po}.

DISCUSSION AND COMPARISONS

17 Concerning the process of developing equations [5] and [6], there is nothing to be added to the brief description in Par. 15. All the data in the several departments of physical experiment were used as checks while the adjustments were being made; and after the formulae were fixed in form and constants, final diagrams were laid out to show, by graphical comparison, the relation of this formulation to the data and to certain other formulations.

18 The comparisons with throttling and specific-heat data are as follows:

a the curve of μ on t, with Davis' curve and points showing his collection of the data into group means, from his paper on The Law of Corresponding States

b the classic throttling experiments made with steam initially superheated, here given as Fig. 7

c the experiments of Dodge upon highly superheated steam. This makes for completeness, but serves chiefly to show lack of determinative value, as the experiments show how extremely difficult it is or will be to get reliable values of μ at high temperatures and pressures

d the Knoblauch-Jakob and Knoblauch-Mollier experiments on specific heat, and the curve of c_{po}

e The experiments of Thomas, which show large inconsistencies.

In every case, only the formulation of the paper enters into these comparisons; except that a few lines (dot-and-dash)in Fig. 7 are from Mollier's heat equation.

19 To illustrate the degree of consistency of results by different methods within the investigation, several diagrams are given:

a Specific heat c_{ps} at saturation, from equation [9] by proper evaluation and also from Planck's equation

$$c_{ps} = \frac{dh_s}{dt} - \frac{r}{T} + \frac{r}{u}\left(\frac{dv}{dt}\right)_p \quad \ldots\ldots\ldots\ldots\ldots\ldots [14$$

The agreement is exceedingly close.

b Isothermals from equation [6] in comparison with those

obtained by the method of Figs. 8 and 9. There is enough discrepancy to illustrate the fact, as does Fig. 7 also, that complete constancy of μ with t is not secured in the final formulation.

20 On the side of volume data, the experiments of Knoblauch, Linde, and Klebe, of Ramsay and Young, and of Battelli are plotted on diagrams of the type of Fig. 1, in comparison with isothermals from equation [5]. The first set are the only ones now having determinative value, but they are of the first importance.

21 The real determinant in the close adjustment of equations [5] and [6] to each other was the satisfaction of Clapeyron's relation. In this connection it was found desirable to make a slight adjust-

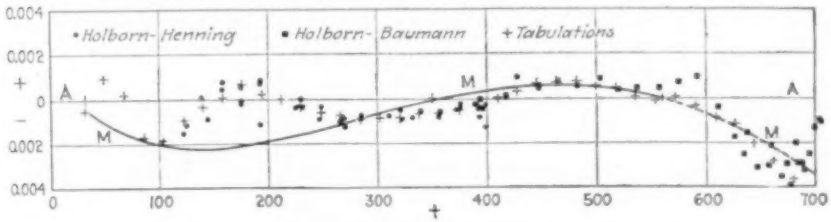

FIG. 10 PRESSURE-TEMPERATURE COMPARISONS

ment of Marks' equation for the pressure-temperature relation of saturated steam. This formula is

$$\log p = A - \frac{B}{T} - CT + DT^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots [15]$$

and the two sets of constants are

	(a) Marks	(b) Heck
$A =$	10.515345	10.606400
$\log B =$	3.6878597	3.6897500
$\log C =$	7.6075880 − 10	7.6205462 − 10
$\log D =$	4.1439400 − 10	4.1601803 − 10

The absolute temperature is taken as $T = t + 459.64$.

22 These equations are compared in Fig. 10, where straight line AA represents equation [15b] and the ordinate is fraction of departure from p as given by this formula. Curve MM is the original Marks equation, and the plotted points show the data. A principal reason for making the change is that [15a] makes $p = 14.672$ lb. at 212 deg. instead of the proper value 14.697.

23 Various evaluations and tabulations of total heat h_s at saturation are compared in Fig. 11. The base lines AA represent equation [6]; but here the ordinate is the actual difference in B.t.u., not the relative difference as in Fig. 10. The curves on the upper AA line

are concerned with the matter of adjusting equations [5] and [6]. Curve 1 shows h_s as derived from h_o by the method of Figs. 8 and 9. Curve 2 is the real criterion of consistency between the principal equations, for it represents the total heat derived from volume data, or from equation [5]. Up to 500 deg. or about 600 lb. pressure, the

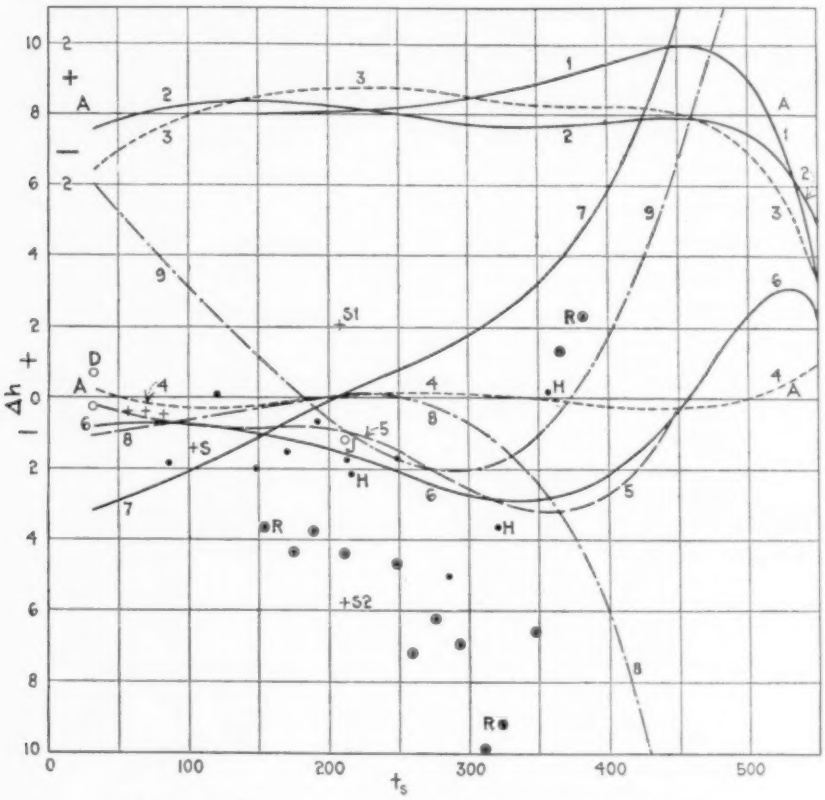

FIG. 11 COMPARISONS OF TOTAL HEAT AT SATURATION

discrepancy is everywhere less than 0.5 B.t.u., or barely exceeds 0.03 per cent. Curve 3 shows results of the same calculation, but made with values of p and r/u from the original Marks equation.

24 The curves referred to the lower AA line in Fig. 11 are of wider scope. First, Curve 4 shows how very nearly h_s from equation [6] is represented by the third-degree equation

$$h_s = 1059.75 + 0.4344\ t + 0.0001829\ t^2 - 0.0000009215\ t^3 \ldots\ldots [16]$$

The curves with numbers higher than 4 represent other formulations, as follows:

No. 5 Marks and Davis *Steam Tables*

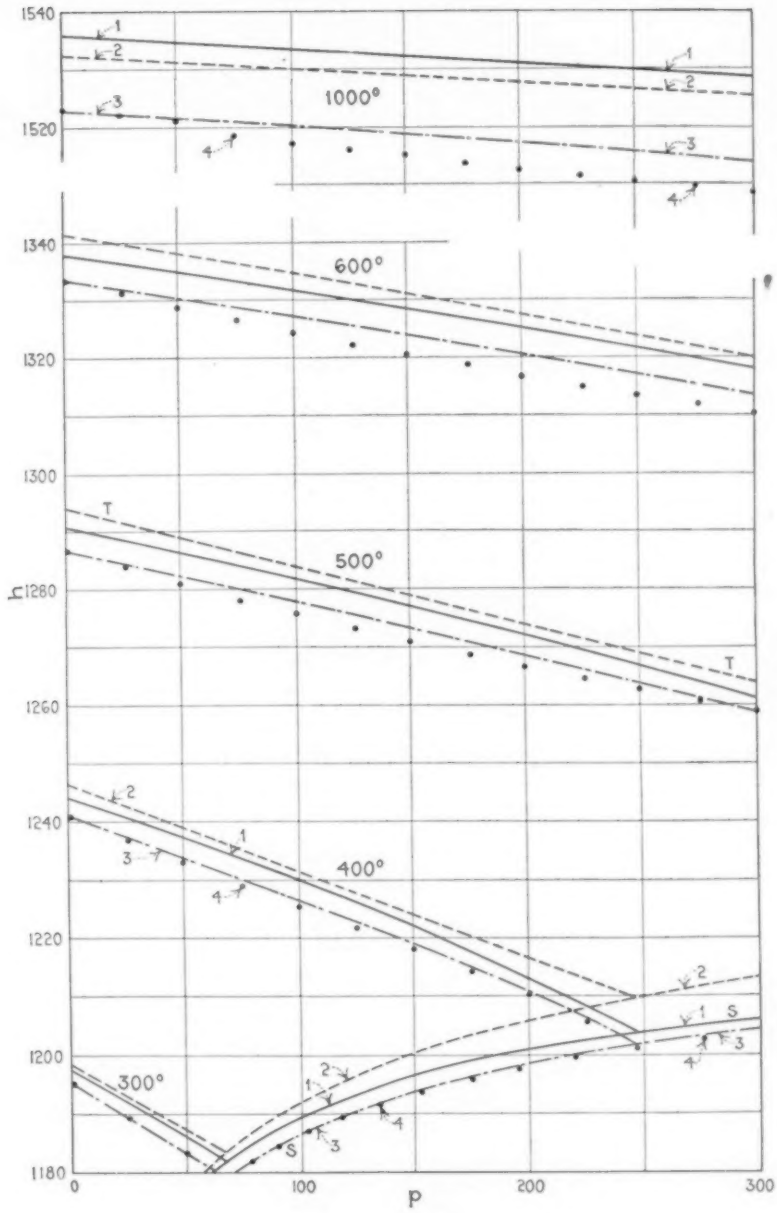

FIG. 12 TOTAL HEAT COMPARISONS

No. 6 the writer's table in *The Steam Engine and Turbine*
No. 7 Mollier's *Neue Tabellen und Diagramme für Wasserdampf*, also Smith and Warren's *New Steam Tables*
No. 8 a heat equation from the work of Linde
No. 9 Goodenough's equation, published in Transactions of the Society, Volume 34.

25 With these curves are given the experimental results obtained by various investigators: the initials used are, *D* for Dieterici, *H* for Henning, *J* for Joly, *R* for Regnault, *S* for Smith. The Regnault points represent group averages made up by Smith. The points marked *S*1 and *S*2 are of especial interest, as representing A. W. Smith's recent determinations with slow and with rapid vaporization under atmospheric pressure, reported in Physical Review, September 1911. The determining value of h_s at 212 deg. is 1151.2 B.t.u. by equations [6] and [7] as against 1150.4 by Marks and Davis and 1151.4 used by Mollier.

26 In Fig. 12 a comparison over the practical range of steam pressure and temperature is made between the heat equations of this paper and those of the other formulation which have been put into the form of complete steam tables. Full lines 1 represent equation [6], dotted lines 2 the Mollier equation; curves 3 are from the writer's[1], earlier work points 4 from the Marks and Davis tables for superheated steam. Mollier's saturation curve runs high (compare Fig. 11), and his isothermals are straight lines instead of curves. The Marks and Davis total heats depend upon a wholly empirical and graphical extrapolation of c_p above the comparatively low pressures of the Knoblauch experiments; and the reversed curvature of the isothermals shows that their c_p is relatively too great at high pressures and near to saturation. In the writer's earlier work, a graphical layout and extrapolation of c_p was guided by heat isothermals obtained through the method of the general throttling curve. Dependence upon the Holborn-Henning determination of high range c_p for atmospheric pressure is the reason why isothermals 3 and 4 at 1000 deg. are about 15 B.t.u. below No. 1.

27 Fuller discussion and comparison of the different formulations are given in the paper. To it is appended tables giving at intervals of 10 deg. up to 1000 deg. all the numbers for making calculations by equations [5] and [6] and their derivatives, with pressure factors up to 1000 lb.; also a table for saturated steam at similar intervals up to 550 deg. or past 1000 lb.

[1] Steam Engine and Turbine.

CAST IRON FOR MACHINE-TOOL PARTS

By Henry M. Wood

ABSTRACT OF PAPER

As this paper treats the subject of cast iron from the viewpoint of the machine-tool manufacturer and user, foundry technicalities have been avoided. A brief outline of the influence of different elements on ordinary cast iron is presented so that manufacturers who are not closely in touch with foundry practice may better understand the analyses quoted later.

Letters from several representative machine-tool manufacturers are quoted, giving their practices in the use of various mixtures, with chemical analyses of irons used for special purposes.

Reports are also presented from a number of manufacturers on the use of chilled castings, which show a considerable difference of opinion, but indicate in general that the use of chills for certain surfaces of machine tools is on the increase.

CAST IRON FOR MACHINE-TOOL PARTS

By Henry M. Wood, Cincinnati, Ohio

Associate Member of the Society

When considering what sort of iron to use for various purposes, the machine-tool manufacturer is interested chiefly in the result attained by the foundryman, i. e., the strength, soundness, hardness, etc., of the casting, rather than the foundry methods used in accomplishing such result. Nevertheless as an investigation of the character of the casting is made through chemical analysis, it is well first to consider the effect of each of the elements usually present in cast iron.

INFLUENCE OF CHEMICAL ELEMENTS

2 The five elements present in ordinary cast iron are carbon (both free as graphite and combined), silicon, sulphur, manganese, and phosphorus.

3 *Carbon.* Carbon exerts a more important and direct influence on the quality of the metal than does any other element. The percentage of carbon in the casting and the form in which it exists are dependent upon the melting conditions, the thermal treatment, and the amounts of other elements present. It is therefore necessary to take account of the effects of the carbon itself and the way its influence is modified by the presence of varying quantities of other elements. To obtain a proper relation between combined and free carbon is the most important point. The percentage of total carbon usually ranges from 3.5 to 4.

4 *Graphitic Carbon.* Graphite is merely mixed with the iron instead of being in chemical combination. Since it is only mixed with the metal it cannot exert any direct influence upon the properties of the molecules of the iron. So far as the graphite itself is concerned the toughness, hardness, and melting point of the grains of

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the iron will not be altered. The tensile strength will, however, be greatly affected, since the interposition of the flakes of graphite will act as partings between the grains of the metal and reduce the cohesion. Iron high in graphite is soft and can be readily machined, but is of low tensile strength.

5 *Combined Carbon.* The carbon which is in chemical combination affects directly and greatly the properties of ordinary cast iron. It is the principal factor in determining the hardness, tenacity, soundness, and freedom from internal stresses of the castings. In general the percentage of combined carbon ranges from 0.05 in the softest cast iron to about 0.60 in iron of the highest elasticity. With suitable iron mixtures the amount of silicon and sulphur present regulates separation of carbon as graphite so that the amount of silicon present is an index of the relation between the free and combined carbon. Many analyses submitted do not state the percentage of carbon, perhaps because the foundrymen do not appreciate the importance of it, or perhaps because they consider the quantities of silicon, manganese and sulphur, which influence the quantity of combined carbon, make it unnecessary to determine the latter.

6 *Silicon.* Silicon tends to cause separation of the carbon as graphite. As the hardening effect of the silicon necessary to do this is less than that of the combined carbon converted into free carbon the net result of adding silicon is softer iron. Under conditions which are easily regulated by selection of materials and in other convenient ways, the general influence of silicon can be utilized to render the cast iron suitable to various purposes, but it must be used with due regard to the other constituents of the metal.

7 *Sulphur.* The influence of sulphur is opposite to silicon, in that it makes the iron harder and more brittle. It makes the iron more sluggish when pouring and is liable to cause unsound castings. Sulphur increases shrinkage, resulting in internal stresses of unknown value and sometimes producing distorted castings. This element should be kept low, especially in small castings.

8 *Manganese.* One effect of manganese is to combine with sulphur and go off in the slag. Another is to retard the separation of graphite by combining with carbon, and in this its influence is opposite to that of silicon, rendering the iron harder, stronger and perhaps closer.

9 *Phosphorus.* Phosphorus lowers the melting point and increases the fluidity of the molten iron. On the other hand, phos-

phorus makes the casting harder, more crystalline and brittle, and reduces the tensile strength.

SPECIAL MIXTURES

10 *Semi-Steel.* This mixture is obtained by charging mild steel scrap into the cupola. It is common practice to use about 20 per cent steel, but any amount up to 70 per cent may be used. The 20 per cent mixture usually gives the desired results for machine-tool work. Semi-steel is lower in total carbon than cast iron, seldom having more than 3 per cent. The fine grain of semi-steel is due to low percentage and fineness of graphite. It is used for parts requiring good appearance, tensile strength, and ability to resist shock. It is often used for large gear blank castings for various machine tools, for milling-machine tables, knees, and saddles, for lathe reverse plates, compound rests, etc. Tensile strength is relatively high and the grain of the casting is close.

11 *Alloys.* Elements sometimes introduced into cast iron for special purposes are vanadium, titanium, nickel and chromium. Vanadium increases the ability of the casting to resist wear. Titanium combines with nitrogen and goes off in the slag, thus acting as a scavenger and making closer and cleaner iron. While nickel and chromium are now used to a limited extent in heavy chilled castings such as car wheels and rolling-mill rolls, the writer has been unable to find instances of the use of these metals in cast iron for machine-tool parts or for similar purposes. Their use might be desirable for special castings as it would doubtless increase the strength. But for machine-tool work the additional expense of such alloy castings might not be warranted, as today all parts where high tensile strength is required are made of steel.

MIXTURES USED BY REPRESENTATIVE MACHINE-TOOL MAKERS

12 In the belief that valuable information could be secured by a comparison of the present practices of representative machine-tool manufacturers, the writer asked a number of machine-tool makers in different lines and in different sections of the country if they would be willing to submit an outline of their practice. The following excerpts pertaining to the mixtures used and chemical analyses of the castings are quoted from their replies:

13 *A Builder of Special Machine Tools:* Our iron is bought on analysis specifications, covering two grades as follows:

Two Plain	
Silicon	1.75 to 2.25
Manganese	0.60 to 0.90

Phosphorus	0.50 to 0.80
Sulphur	0.05 and under

No. 3

Silicon	1.00 to 1.50
Manganese	0.50 and over
Phosphorus	0.50 to 0.80
Sulphur	0.07 and under

In addition to the above we use materials as follows: No. 1 machinery scrap, mild steel scrap, manganese steel scrap. The last carries 12 per cent of manganese with quantities of the other elements so small that they are negligible in gray iron foundry work.

14 Our mixtures are figured out on the actual analysis of each car, insuring in the castings uniformity of analysis and consequently of physical characteristics, such as strength, density, and machining qualities. In general practice we use three different mixtures suited to our varying needs.

15 In our first mixture we include our lighter castings such as pulleys, small gears, washers, hand-wheels, brackets, and the like. In this mixture we endeavor to have the following analysis:

Silicon	1.90
Manganese	0.60
Phosphorus	0.70
Sulphur	0.08

This is usually secured by the use of a mixture of 50 per cent of two or three lots of two plain iron and 50 per cent of scrap. The proportions of the different pig irons are adjusted to produce the proper analysis in the mixture, and the scrap is partly our own foundry return and the balance No. 1 machinery scrap.

16 Our second mixture covers all our heavy work, such as planer beds, posts, tables, face plates, frames, etc. These castings require strength and sufficient density to permit the machined surface to take a high polish. These ends we accomplish by an analysis as follows:

Silicon	1.40
Manganese	0.60
Phosphorus	0.60
Sulphur	0.09

This mixture consists of 45 per cent of two or more No. 3 irons and 55 per cent total scrap, shop and No. 1 machinery together. Should this mixture fail to yield sufficient manganese the addition of 1 to 2 per cent of manganese steel scrap is made to correct it.

17 The third mixture is semi-steel, used principally for large blank gears and castings requiring special strength. Its analysis is

Silicon	1.20
Manganese	0.90
Phosphorus	0.45
Sulphur	0.09

Its average makeup is

	Per Cent
Machinery scrap	30
Mild steel scrap	20

Manganese steel scrap	5
No. 3 pig iron	45

18 The above mixtures cover our entire range of work except cases where some special composition is required or desired.

19 All materials are weighed before charging into the cupola and all due precautions are taken to insure proper melting conditions and perfect mixtures of the various materials entering into each charge.

20 *A Manufacturer of Precision Machinery:* In our work we run various grades of iron to meet the conditions existing in the machines or in the parts of machines under consideration.

21 In a general way our mixtures, in per cent, run as follows:

Silicon	Manganese	Phosphorus
3.00	0.60	0.80
2.40	0.65	0.70
2.00	0.65	0.60

The first is for the average run of castings of smaller size; the second for the larger castings. Where we need a special close-grain iron we use the third mixture.

22 *A Manufacturer of Milling Machines:* We have never carried on any extensive experiments to learn the best mixtures of cast iron for our purposes. We use in the tables, knees, saddles and vises about 20 per cent of steel with a view to obtaining a close-grain casting, and increasing somewhat its strength.

23 We use practically no cast iron for gears or small parts, these being made of steel drop forged in the case of larger parts, and also in the case of smaller parts when not adopted for manufacture from the bar.

24 The subject of gray-iron castings is, we believe, one of the most annoying to be found in connection with the manufacture of machine tools. Customers are not satisfied to accept machines with defective castings even though the deficiency is of such a nature as to, in no wise, impair the life or efficiency of the machine.

25 The ideal casting is, of course, one that is so close as not to show any grain when finished and at the same time, just as hard as it can be, and be worked into shape.

26 The question of strength is probably not so important, as there is opportunity to use sufficient bulk to obtain strength. At any rate this is true of the parts that we make of cast iron, for, as stated above, all our gears and like parts are made from steel which is casehardened.

27 *A Manufacturer of Heavy Lathes:* With the heavier castings we are using a semi-steel mixture with about 20 per cent of steel. The analysis of this iron shows 1.60 to 1.70 silicon, 0.65 to 0.75 manganese, 0.40 phosphorus, 0.8 to 0.10 sulphur. While our carbons are not noted as a rule, we get a check on these every once in a while, showing the total carbons about 3.50 to 3.60.

28 Our iron for smaller pieces runs from 1.80 to 1.90 in silicon, 0.40 to 0.50 in phosphorus, 0.65 to 0.70 manganese, 0.07 to 0.10 in sulphur. The total carbon shows up practically the same in both mixtures. Our test bars on the first mixture break at from 2800 to 3200 and on the latter mixtures at about 2600. This refers to 1 in. by 1 in. standard bars supported on 12 in. centers.

29 *A Manufacturer of Grinding Machines:* We use castings with various proportions of steel according to the size of the casting and the place where it is to

be used, so that today we have very bright lustrous surfaces and it is possible to get accurate alignment.

PRACTICE WITH REFERENCE TO CHILLING CASTINGS

30 There is a wide difference of opinion among machine-tool manufacturers as to the desirability of chilling any surfaces of castings. The writer asked some of the representative manufacturers of various classes of machine tools for their experience on this point. The following quotations from their replies state both sides of the case:

31 *A Manufacturer of Milling Machines:* We are not using any chills at this time, though we have experimented with these from time to time but have reached no satisfactory conclusion.

32 *A Lathe Manufacturer:* We have not used chills on any parts of our machines, which, we must concede, is from many points of view, not a very satisfactory admission to make.

33 *A Manufacturer of Heavy Machine Tools:* For quite a period, about nine or ten years ago, we chilled the ways on our lathe and also the rails on our boring mills. We found, however, after they had been out some time that there was quite a bit of trouble with the chilled surfaces scratching. It was hard for us to find exactly what was the root of the trouble and we finally gave it up. The effect of the scratching of the chilled ways was a most peculiar one, and we sometimes observed on a machine even before it had gone out that some little particle of material had settled on the way and scratched the same badly.

34 *A Manufacturer of Grinding Machines:* In regard to chilled iron, of course, you know that chilled iron means this and nothing else: It means iron that cannot be filed, planed or scraped. At least any mechanic who hears the words "chilled iron" understands it to mean just that thing, a surface that cannot be cut with tools. Now, of course, you realize that such a surface makes it impossible to get practical aligning ways on machine tools. It might just barely be possible to grind them accurately, but probably not practical to do so. We use an iron with steel mixture, and vary the mixture according to the size of the casting, and we produce a casting as dense and as hard as we can possibly plane and scrape with any surety of getting perfect alignment, because imperfect bearing and imperfect alignment is just as bad and just as sure an error as iron that would be too soft. In fact if one had iron that was exceedingly soft, and should choose to make ways which are very wide it might be more durable than one made with hard iron and smaller ways.

35 *Another Manufacturer of Grinding Machines:* The main reason for chilling the different parts of our work is to increase the wearing durability and at the same time get the advantage of refining the metal and a clean surface. The parts chilled are the guides of the carriage and the surface of the table upon which the head and tailstocks are mounted.

36 Our method of chilling is to place plates of $\frac{5}{8}$ in. in thickness in the mold, and these give a depth of chill of about $\frac{1}{2}$ in. and a degree of hardness just to the point of where the machining can be readily done.

37 It would be natural to suppose that this chilling would produce or increase internal strains, but on our work, such conditions have not given any trouble.

38 Our work is not of such a nature where hammering upon it or peening is necessary. Therefore, we are unable to state just what action would take place as the result of hammer blows and peening.

39 The chilled surfaces are very much more durable than metal in the ordinary condition, and we believe by the chilling process the durability of the surface upon which wear comes is increased at least from 300 to 400 per cent.

40 *A Builder of Heavy Machine Tools:* In 1888 we began the practice of solidifying cast-iron surfaces by introducing chill blocks in the molds, and we have continued the practice ever since.

41 Answering your questions specifically, first, we have not discontinued the use of chilled surfaces because of any difficulty in oiling. We have never found that the fine grain of the chilled iron prevented the oil from sticking. There is no truth in the statement.

42 We have not found any increase in internal strains due to the use of chills. On the contrary, when chills are properly placed they equalize the cooling of the heavy parts adjacent to lighter portions and reduce the internal stresses which would naturally result from the difference in time of cooling. If the chills are improperly used it would be possible, especially in thin castings, to cool the entire mass too rapidly and produce internal stresses.

43 We have not found that the proper use of chills makes the iron more sensitive to a peening action; in fact, we have evidence to the contrary.

44 The chilled surface we believe to be more durable. We have cases where gearing made in this way outlasted several sets made in the old manner.

45 The success or failure of this process depends upon the ability to produce, day in and day out, the kind of metal required, and, further, the intelligent designing of chills of iron molds so that a proper relation may always be observed between the size and shape of the casting and the thickness of the mold or chill block.

46 *A Boring-Mill Manufacturer:* We are chilling certain surfaces on our boring-mill spindles with good success, but have found no occasion for chilling any other surfaces. If we experienced difficulty due to undue wear on sliding surfaces, we would increase the area of the surfaces and supply better lubrication and protection from dirt rather than to try to chill the surfaces of these parts.

47 The chills which we use on our spindles serve two purposes: first, by securing closer grained metal; second, by improving the quality of the wearing surfaces. We found that it was difficult to get good castings of these spindles until we did use chills.

48 *A Builder of Special Machine Tools:* Concerning chills, we would say that to some extent we are now using these on the surfaces of beds and similar castings.

49 *A Manufacturer of Precision Machinery:* We use such chills as may be necessary to give the surface in connection with the ways and moving parts.

CHILLED LATHE BEDS

50 *Analysis of Iron.* In view of the considerable differences in opinions of the value of chilled surfaces and the idea held by some that it is impossible to chill an iron of high tensile strength without making it so hard it cannot be machined, the practice of The Lodge

& Shipley Machine Tool Company, with which the writer is connected, is here outlined.

51 Three average analyses are as follows:

Silicon	Sulphur	Phosphorus	Manganese	Tensile Strength
2.16	0.065	1.01	0.40	22,310
2.17	0.065	1.01	0.39	24,840
2.45	0.076	0.63	0.71	24,195

The first analysis is of a specimen taken in January 1913 from the first iron run in a heat; the second, from the last iron of the same

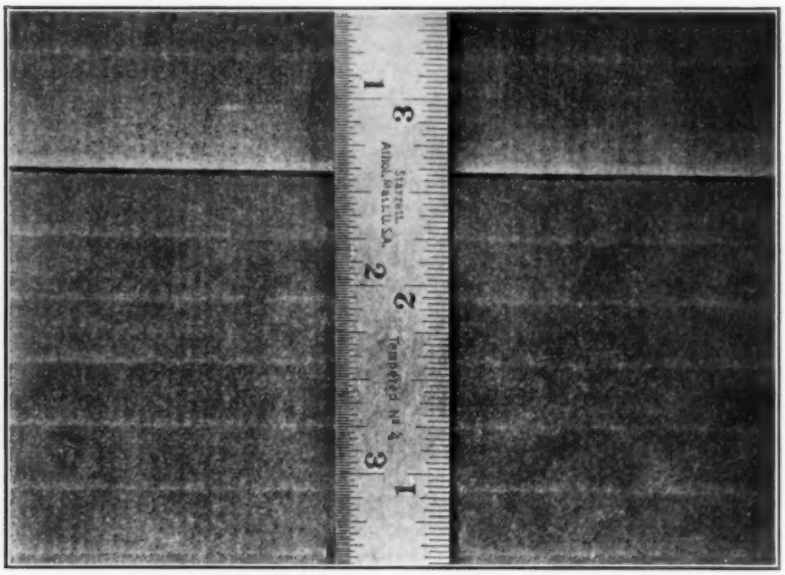

FIG. 1 CHILLED CASTING, FINISH PLANED BUT NOT SCRAPED

heat; the third, from the average iron of a heat in September 1913.

52 This same iron is used for lathe beds of which the ways are chilled, also for other cast-iron parts which do not require the high tensile strength of semi-steel. For some parts, such as compound rest top slides and reverse plates, we use semi-steel. Parts subject to greater stress or to severe shock are made of steel.

53 *Appearance of Chilled Surface.* A portion of the finished way of the lathe bed as it comes off the planer and before scraping is shown in Fig. 1. A steel scale is laid on the surface to indicate the closeness to actual size with which this is reproduced. A comparison with the 1/64 in. graduations on the scale shows the extremely close even grain of this chilled surface.

54 The exact effect of the chill on a casting is well illustrated in Fig. 2. This shows the cross-sectional fracture through the finished ways and a portion of the side wall of the chilled bed for a 30-in. lathe. The reproduction clearly shows that the iron even far away from the chill in the side wall of the casting is dense and of as close grain as other good cast iron; it also shows the much closer grain of

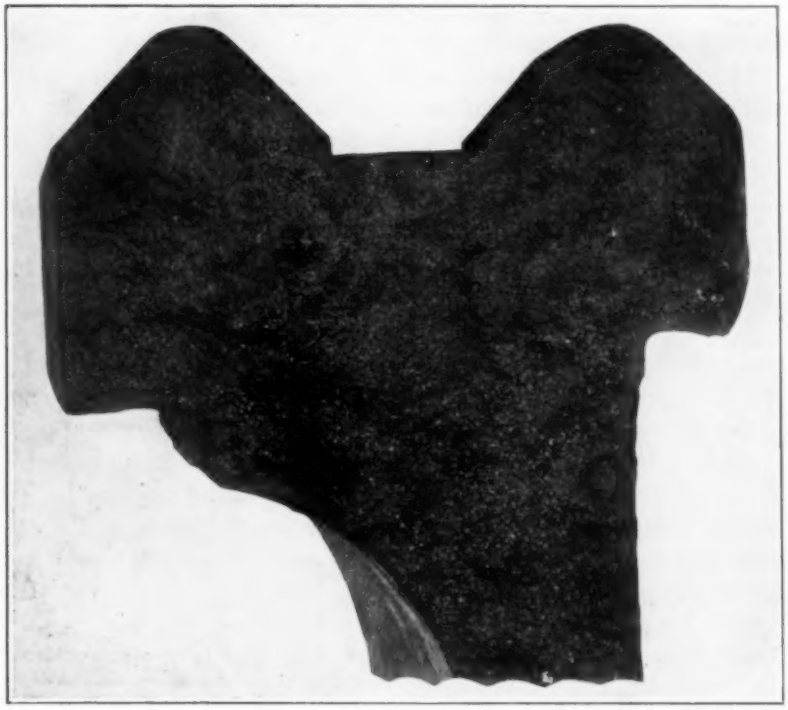

FIG. 2 CROSS-SECTIONAL FRACTURE OF CHILLED LATHE-BED

the iron below the finished surface as a result of the chill in closing up the iron and making it harder and more durable. In the 30-in. bed, as plainly shown by this specimen, the close iron produced by the chill extends to a depth of 1½ in. to 2 in. below the finished surface of the ways, thus proving that the chilled iron is not all removed in the planing.

55 *Degree of Hardness.* Scleroscope test on chilled beds finish planed but not scraped gave as a result of eight different tests on four different beds, scleroscope readings of 40 to 42 with an average of 41. Similar tests on chilled beds which had been planed and then

scraped gave a practically constant scleroscope reading of 42. Comparative scleroscope tests on a heavy section of unchilled cast iron which would give as nearly as possible conditions parallel to those just quoted gave readings ranging from 18 to 22, with an average of 20.

56 These tests indicate that the chilled ways are twice as hard as the unchilled. The same is also shown by the planing speed, as we can only plane the chilled beds at a trifle less than half the cutting speed formerly used.

57 In addition to the advantage gained by the hardness, the chilled beds are if anything more uniform than the unchilled. The rough beds as received from the foundry are quite straight, so that the amount of metal removed all along the ways in planing is as nearly uniform as is practicable. Then, too, the scleroscope readings indicated a more nearly constant degree of hardness on the chilled beds than on the unchilled. Fewer castings are unsound than before chills were used.

58 *Action of the Chill.* The chilled surface is produced by a series of cast-iron chill plates each about 6 in. long placed end to end in the mold. The use of separate short plates eliminates much of the warping and twisting which would occur in a long chill plate.

59 If a thick chill plate is used with a low-silicon iron the surface of the casting is chilled so hard that it cannot be machined. The desired result is attained by regulating the thickness of the chill plate to suit the size of the casting for which it is used; then a low-silicon iron of high tensile strength can be successfully poured. The heavier the casting, the thicker the chill plate.

60 The action in the mold is that when the molten iron strikes the cold plate it is chilled and hardened; then the heat in the mass of iron forming the body of the bed casting gradually warms the chilled surface and the chill plate, thus annealing the casting or "drawing the chill," just as when in tempering a chisel the heat in the shank of the chisel "draws the temper" of the cutting edge to the proper point after the cutting edge has been hardened by quenching in water. This annealing of the chilled surface of the casting produces the desired form of hard, close-grained gray iron.

61 The thickness of the chill plate used is such that the heat in the casting will anneal the surface sufficiently to permit planing, although at a greatly reduced cutting speed, and yet retain the benefits of the chill.

VALUE OF CHILLED SURFACES

62 The advantages of chilled wearing surfaces for machine tools are:

a Much harder surfaces, which experience has proved are vastly more durable than similar unchilled surfaces.

b A hard guiding surface with a relatively soft carriage, bringing the bulk of the wear on the carriage and thus maintaining the alignment of the guide.

c A denser and much more closely grained surface of the casting, giving better appearance.

d An exceptionally smooth finished surface, in which there are no pores where dirt and grit may become imbedded to cause rapid abrasion of the other bearing surface.

63 There are several ways of increasing the durability of working parts, such as by increasing the area of the bearing, by providing more complete lubrication, and by hardening the surfaces. All are successfully used. In general, each method may be used independently of the others. If the areas of the surfaces are as large as special conditions permit, and if the lubrication is thoroughly efficient, there would seem to be no objection to still further increasing the durability by the use of chills.

64 Chilled surfaces are more advantageous on some machines and some parts than on others. In the case of a lathe the carriage will often be used for long periods of time on chuck work or on short jobs between centers which brings all of the wear on a comparatively short length of the bed just in front of the headstock; such uneven wear on the unchilled bed destroys the accuracy of the alignment for long work. Chilling the ways brings the wear principally upon the carriage, and even if the carriage is worn, the alignment at all points along the bed will remain relatively true.

65 Only one manufacturer (see Par. 33) of all who were kind enough to reply on this subject had discontinued the use of chills; the others who are using chills do not report any trouble due to scratching. The objections to the use of chills aside from the one instance quoted, have come from foundrymen who do not and have not used chills.

66 Our own experience, based on the use of chilled ways on beds of all sizes of our lathes for more than two years, is that no internal stresses are created by the chilling; that the surface is not made more susceptible to a peening action; that the surface can be equally as well lubricated as before; that iron of high tensile strength is used;

and that the increased hardness and closeness of grain of the chilled surface vastly increases the durability and permanency of alignment. We find no disadvantage except a somewhat increased cost.

TENSILE STRENGTHS OF VARIOUS IRONS

67 As the letters received from other machine-tool manufacturers do not state tensile strengths, the following statements regarding the general practice of Cincinnati manufacturers are quoted:

68 *A Professor of Mechanical Engineering and Testing:* I believe the general Cincinnati machine-tool practice for good castings runs from 22,000 to 24,000 lb. per sq. in. tensile strength, but owing to the great variety I would not wish to commit myself to any particular figures.

69 *A Cincinnati Chemist:* After tabulating the results of my tests of the tensile strength of cast iron from various sources, I pick some at random to show the average run of machine-tool iron in lb. per sq. in. in this locality: 22,962; 24,090; 24,522; 23,197; 23,260.

70 This will give an idea of what the general run is. Good machineable iron, where the grain does not have to be too close for machine-tool work, should run from 20,000 to 26,000 lb. per sq. in. Low tensile strength is due to too much silicon, sulphur, or phosphorus.

CONCLUSIONS

71 Chilled surfaces for certain parts are desirable. There might be a limited field for special alloy castings and if any machine-tool manufacturers have experimented with them, the results of their tests would be welcome. There is a wide difference in the chemical analyses of irons used by representative manufacturers—this last circumstance may be due to the different melting conditions in the several foundries; or it may indicate a field where much good could be accomplished by a more complete interchange of information, and by experiments to determine the best mixtures for different purposes.

GEARS FOR MACHINE-TOOL DRIVES

By John Parker

ABSTRACT OF PAPER

This paper deals with the important subject of selecting the proper material for gears in accordance with the best modern machine-tool practice. The method of heat treating and hardening steel gears is fully explained, and the proper hardness by the scleroscope test for the different stages is given.

GEARS FOR MACHINE-TOOL DRIVES

By John Parker, Providence, R. I.

Member of the Society

The basis of this paper is the consideration of the following six questions relating to the use of gears for driving machine tools:

1 Under what conditions is it advisable to use cast-iron or steel gears for machine-tool drives?

2 Are the objections to cast-iron on the ground of wear or breakage?

3 What tooth pressure is safe for cast-iron gears?

4 What grades of steel give best results and how should they be treated?

5 How hard is it advisable to make steel gears before machining them?

6 Are they to be hardened after machining, and if so, to what scleroscope test?

2 *Conditions under which it is Advisable to use Cast-Iron or Steel Gears for Machine-Tool Drives.* There are a number of well established gear conditions that are common to the majority of machine tools, which if noted may prove somewhat of a guide in selecting the proper material for the gears, considered from the standpoints of economy, efficiency, and durability. The conditions may be classified, as in Table 1.

3 *The Objections to Cast Iron.* The objections to cast iron cover both wear and breakage. If the speed is excessive, say above 500 ft. per minute, they are likely to wear quite rapidly; and on slow speeds and heavy pressure breakage will occur, unless they can be made of adequate size, as in the case *E*, where the back gears are so located in the machine that it is possible to employ large diameters, coarse pitches, and wide faces.

4 *The Safe Tooth Pressure for Cast-Iron Gears.* The question of tooth pressures in cast-iron gears is somewhat problematical. The

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

TABLE 1 GEAR CONDITIONS COMMON IN MACHINE TOOLS

			Material
A	Gears always in mesh, the wear on the teeth being constant	(*a*) Slow speeds, light duty	Cast iron
		(*b*) Slow speeds, heavy duty	Machinery steel
		(*c*) Fast speeds, light duty	Machinery steel
		(*d*) Fast speeds, heavy duty	Machinery steel, casehardened
B	Gears in sets that are removable and interchangeable with each other, distributing the wear over a number of gears	These are change gears used in thread cutting on lathes, spiral cutting on milling machines, indexing on automatic gear cutters and feed and speed change gears; speeds and pressures are generally moderate	Cast iron, excepting the smallest, which may require to be of steel
C	Gears in sets that are nonremovable and partially interchangeable, distributing the wear over a number of gears. Changes made while gears are in motion [1]	Used as quick-change feed gears—changes made by levers; speeds and pressures moderate	Machinery steel, casehardened
D	Gears in sets that are nonremovable and partially interchangeable, distributing the wear over a number of gears. Changes made when gears are at rest [2]	Used as quick-change speed gears—changes made by levers; high speeds and heavy pressure	Machinery steel, casehardened
E	Gears that are employed only part of the time the machine is working, and are engaged and disengaged when the machine is stopped	This condition applies to back gears for the spindle drive. Gears are made large diameter, coarse pitch and wide face; speeds moderate and heavy pressure	Hard, close-grained cast iron

[1] If the changes were made when the machine was at rest, the gears would not require hardening. But custom demands that changes be made while the machine is running.

[2] Although the changes are supposed to be made when gears are at rest, careless workmen will violate this rule, with the possibility of breaking the engaging gears. Some makers use an alloy steel in their spindle train to prevent breakage, but a better way is to provide means whereby it is necessary to stop the machine before throwing in the gears. This applies to the tumbler type of change gearing.

Brown & Sharpe Manufacturing Company have in successful operation a gear in the spindle drive of their largest milling machine made from a hard, close-grained cast iron having a tensile strength of 23,000 lb. per sq. in., which when running at the slowest speed sustains a pressure on the teeth of 8250 lb. It is calculated that two teeth are always in contact, which gives 4125 lb. pressure per tooth. The area in cross-section of each tooth is $1\frac{1}{4}$ sq. in., equaling 3300 lb. per sq. in.; when the gear runs at the fastest speed the pressure is about 1000 lb. per sq. in. It is not known whether the pressure could be increased to any considerable extent, but it has been overloaded to at least 30 per cent without injuring it; this was when testing out the machine and the overload was of short duration. It might be said that this gear is not subjected to any sudden shock; if it were, the allowable tooth pressure would be considerably less.

5 *The Grades of Steel that have given Best Results and how They have been treated.* For gears that are of small proportions and yet are subjected to heavy duty, it has been found that in cases where the more common steels have failed, excellent results have been obtained from using a 5 per cent nickel steel. This steel casehardens with a very hard surface and still has a strong and tough core, making it an ideal steel to use where the pressure is heavy or the gear is subjected to shock. Experience shows that drop forgings are more uniform in texture than bar stock. This grade of steel is given an oil treatment and is also annealed before machining; the oil treatment is as follows: heat to 1550 deg. fahr. and quench in oil. To anneal, reheat to 1350 deg. fahr. and cool very slowly. It is then ready to machine.

6 After machining, it is carbonized as follows: pack in any good carbonizing material and cover very carefully to exclude air, place in furnace and heat to 1700 deg. fahr., and hold long enough to get the desired depth of casing. Care should be taken to have it heated entirely through. Ordinarily three to four hours will suffice for this process. Then take out of furnace and cool off in the boxes; remove from the boxes and place in furnace or bath; reheat to 1550 deg. fahr. and quench in oil. Again reheat to about 1380 deg. fahr. and quench in oil or water according to the size and shape of gear. If the gear is of generous dimensions and free from sharp corners, water is preferably used. Small slender gears are quenched in oil, on account of the liability of cracking if water is used. For ordinary gears the scleroscope test should show 80 to 85 points of hardness. If the gears are used as clash gears they should be drawn to 475 deg. fahr., or about 70 to 75 points of hardness, by scleroscope test, to avoid chipping.

7 *Degree of Hardness Advisable for Steel Gears before Machining Them.* The various kinds of steels used for gears are of such a nature that they do not call for treating before machining, but where extra toughness in shafts is required to withstand torsion and bending strains, 3½ per cent nickel steel is very satisfactory. This grade of steel is rough machined, then heat treated, as follows: place in open furnace or bath, heat to 1500 deg. fahr., and quench in oil. It is advisable to experiment with a small quantity in each batch before subjecting a whole lot to the drawing out heat, which should commence at about 700 deg. fahr. If the scleroscope registers between 50 and 58, the correct hardness has been obtained; if higher than 58, the parts should be reheated to a higher temperature than before; if lower than 50, the parts must be rehardened. After this treatment, the pieces are finish machined. No further hardening is necessary. When machining, slow speeds and feeds must be used.

8 *Hardening After Machining, and the Scleroscope Test.* Practically all alloy steels and all low-carbon steels are hardened after machining and finished by grinding after hardening. About 0.010 in. on the diameter is left for this operation. All gears should run true, and to obtain this result not only are the holes ground true with the pitch circle, but the hubs are ground on their faces so they will set square with their shafts when tightened up by nuts. The scleroscope test for 30 to 35 point carbon machinery steel is anywhere from 80 to 90, and for 5 per cent nickel steel for ordinary gears 80 to 85, and for clash gears 70 to 75. All steels are tested by the file in addition to the scleroscope. The file test by an expert is very reliable and some feel that possibly more confidence can be placed on his judgment than on any testing instrument.

9 The above notes apply to spur and bevel gears. For worm and worm-wheel drives, the worm should be made of machinery steel, casehardened, and the wheel of a hard bronze. Both should run in a bath of oil, especially if under high speed and heavy duty. Spiral gears should be used only where the duty is light. The material should be the same as for a worm and wheel, and they should also run in oil to avoid cutting.

10 For index mechanisms, where accuracy is essential, if the worm is hardened the thread must be ground afterwards. This is done in all the spiral heads of Brown & Sharpe's make. Generally, the worm, made of tool steel, is left soft. Worm wheels used for indexing purposes only are usually made of cast iron, and invariably if of large diameter. High-multiple threaded worms for indexing mechanisms should not be used; a double thread can be tolerated, but not more, if accurate indexings are required.

APPENDIX

A letter embodying the six questions set forth in Par. 1 of the paper was sent out by the Committee on Machine Shop Practice to various machine builders, and the following replies were received:

J. B. DOAN.[1] Nearly all the gears used today in machine-tool construction are of cast iron, although the quantity of steel gears is increasing. The American Tool Works Company use cast iron with slow peripheral speeds and comparatively large diameters; steel for small diameters and high speeds, hardening those which experience teaches need such treatment.

The main objection to cast-iron gears is their breakage, and not so much their wear. A good grade of cast iron shows very good wear. A great many steel pinions are used, some of them hardened, working with cast-iron gears of large diameter, the difference of material compensating in strength for the weakness of the pinion tooth, and also for the wear occasioned by the different number of teeth.

The Lewis formula is used by The American Tool Works Company for tooth pressures on cast-iron gears.

For hardened-steel gears the following method with special gear stock made of very low carbon is employed: The gear is machine finished with an allowance of 0.012 in. on the bore for grinding after being heat treated as follows:

a Pack in round cast-iron box, using 10 per cent charred leather, 40 per cent burnt bone, 50 per cent raw bone
b Seal top with mortar of iron filings and fire clay about 1 in. thick
c Cover with cast-iron lid and lute with clay
d Heat for nine hours to 1560 deg. fahr.
e Remove box from furnace and cool without disturbing contents
f Remove pieces and heat to 1550 deg. fahr. in furnace
g Quench in fish oil
h Draw in tempering oil to 475 deg. fahr.

Gears are hardened after machining and tested with the scleroscope to 80.

J. B. GREEN. Gearing for machine tools is one of the interesting problems in connection with their design and construction. The selection of suitable materials for gears is usually fixed by the character of the machine and its uses. Some machines permit the use of large dimensions, while in others the sizes are often very limited.

The Lewis formula with the modifications made by Carl G. Barth as given in the American Machinist Gear Book, Pages 57 and 58, is the well beaten path usually followed in selecting the best materials for gearing, and when properly used, there is a reasonable field of uses for all materials.

Cast iron can be used in all places where there is sufficient room for the proper dimensions and, when not overloaded, the teeth wear to a polished and glazed

[1] Vice-President and General Manager, The American Tool Works Company, Cincinnati, Ohio.

surface so characteristic of this material. When slightly overloaded, the wearing surface of the teeth becomes crushed and cut at the pitch line and then wears out very rapidly; when considerably overloaded, failure occurs through breakage.

Steel iron, or semi-steel, as it is sometimes called, is made of a mixture of steel and cast iron and when made of the proper proportions, is a very good improvement over cast iron, being strong enough to carry about 50 per cent more load and giving very similar results in regard to wear and breakage.

Low-carbon steel gears will carry from two to two and a half times the load for cast iron; when slightly overloaded they wear a line depression across the face of the teeth at the pitch diameter and when continuously overloaded soon wear out.

Steel gears containing about 20 per cent carbon can be casehardened after being machined; when so treated they will stand considerable use without wear and are especially valuable for pinions meshing into large gears.

The high-carbon and alloy-steel gears will stand loads proportionate with the permissible stresses for the various materials. These steels may be heat treated before machining which will allow large pieces to be greatly toughened and strengthened and then finished to the required accuracy, whereas, if the same pieces were hardened after machining, the resulting distortion would make such an operation impossible.

When the nature of the piece will permit, the alloy steels may be hardened throughout when all machining is completed and then drawn to the proper temper so as to make an almost indestructible gear. The exact hardness or toughness of teeth must be determined by the uses for which the gear is intended and in many cases experiments are necessary.

E. A. Muller. If cast-iron gears were inadequate for their purpose, I should be the first to discard their use. In view, however, of the most excellent results obtained with them, such a move would not be warranted, especially when the substitution of heat-treated alloy-steel gears would simply increase the cost of a machine.

If a large amount of mechanism subjected to heavy loads must be placed in a small compass the cast-iron gear is unequal to the requirements, but in many machine tools much space is available for the driving gears and there is really no excuse for adding to the cost of these machines by designing the equivalent of automobile transmission gears for machine-tool drives.

Since 1893 I have used Wilfred Lewis' formula for safe working pressure on gear teeth with uniformly excellent results. Neither wear nor breakage has been objectionable; in fact, gears in use six years on machines in hard service show no appreciable wear. Cast-iron gears and steel pinions proportioned in accordance with the Lewis formula should not exceed 1200 ft. pitch line velocity. Experience with gears designed by this formula indicates that cast-iron gears can transmit greater horsepower without failure, but that wear begins to increase considerably as the load increases.

The King Machine Tool Company do not use heat-treated or hardened-steel gears at all. In such machinery where ample space is provided for gearing, I do not believe that properly proportioned cast-iron gears and steel pinions can be improved upon. However, where conditions obtain as in automobile transmissions, heat-treated and hardened-steel gears are indispensable.

Another machine builder writes: We find that cast-iron and mild-steel gears

work very satisfactorily for machine-tool drives wherever there is room enough to make them of the proper size to avoid extreme wear. This is particularly true where the gears can run in oil. In general, of two sets of gears of the same dimensions, running under the same load, at the same speed, the one made of unhardened steel will run more smoothly than the one made of hardened steel. The question of hardened versus unhardened gears is therefore one of space and weight limitations. It should be noted that cast iron running with cast iron, or a steel pinion running with a cast-iron gear is a good combination, but that two mild steel gears running together, particularly at high speeds, should be avoided under any circumstances. The soft-steel gears abrade themselves with great rapidity.

The objections to cast iron are on the ground of liability to breakage in the case of work involving hammer blows or sudden or reversed stresses. There is no great objection from the standpoint of wear, where gears of the proper size can be used as indicated in the preceding paragraph, and where constant lubrication is provided.

For ordinary machine tool work we have found by experience that the Lewis formula, with the strength factors originally given, gives gears that are from 25 per cent to 40 per cent too strong.

Harder steels give better results from the standpoint of wear and abrasion as well as of strength. When it becomes necessary to use hardened gears, there is nothing better than to follow automobile practice closely, using chrome nickel or similar materials heat treated in the approved manner.

We should be inclined to anneal them as thoroughly as possible before machining in order to have the tooth surfaces cut as accurately as possible. At the same time, with the shaper tool of the gear shaper it is possible to machine gears for a finishing cut that are heat treated so hard that a file will barely touch them. This is done by several firms, using turpentine as a lubricant, with very good results.

We have found that the scleroscope test is unreliable, and that its indications show very little regarding the matter of hardness for resisting wear, particularly when trying to compare pieces of different shapes or methods of support. Some gear specialists have come to this conclusion also, while others use the instrument with more or less favorable results. We would appreciate further information on this point.

A RECORD OF PRESSED FITS

By C. F. MacGill

ABSTRACT OF PAPER

The paper presents a record of forced fits that have been made in actual practice on electric generators and motor shafts, together with table showing sizes, thickness of hub wall and material used, also formulae used in calculating tension stress, radial pressure and coefficient of friction.

A RECORD OF PRESSED FITS

By C. F. MacGill, St. Louis, Mo.

Member of the Society

Articles on forced or pressed fits have been published in various technical journals of the country during the past ten or twelve years, one by Stanley H. Moore [1] appearing in the Transactions of the Society. In but one of the papers noticed is there any reference to the diameter and length of the hub into which the shaft is forced or the material of which the hub is made, three very important elements in a forced fit. The great difference in allowances recommended, and in the pressures shown in the articles referred to, led me to have an exact record kept of each forced fit, from which were later calculated the tension stress, radial pressure and the coefficient of friction. Table 1 forming part of this paper is the result.

2 In my own experience, covering about 20 years, in charge of shops where forced fits were made, I have found that it was not necessary to increase the allowance with the diameter of the shaft, as the increased surface area of the fit added sufficient friction to bring the pressure up to the required tonnage, and that an allowance of from 0.002 in. to 0.004 in. on steel shafts pressed into steel hubs, and an allowance of from 0.003 in. to 0.005 in. on steel shafts pressed into cast-iron hubs of ordinary hardness, gave good results. I have yet to learn of one of these shafts coming loose.

3 There is no doubt in my mind that allowances greater than 0.006 in. on steel shafts pressed into cast-iron hubs, not only do not serve any useful purpose, but tend to set up strains that are injurious to the casting.

4 One large plant with which I am familiar issues an allowance table for pressed fits, the allowance gradually increasing with the shaft diameter. This is not followed in their shaft department, but instead a flat allowance of 0.003 in. is used without regard to the diameter of the shaft.

[1] Fits and Fitting, vol. 24, p. 1158.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

5 The allowances given by Mr. Moore, in his paper already referred to, are very much too great, while those given by Mr. Riddell[1] in his discussion of the paper are too low for sizes under 12 in.

6 According to Mr. Moore's formula $A = 2D + 0.5$ and shown in his table, the allowance for an 8-in. shaft would be $8 \times 2 + 0.5 = 0.0165$ in., and on a 12-in. shaft $12 \times 2 + 0.5 = 0.0245$ in., and as, from Table 1 of actual fits, an allowance of 0.002 in. on 8-in. shafts pressed into steel hubs showed pressures of from 75 to 110 tons and an allowance of 0.004 in. on a 12-in. shaft pressed into a cast-iron hub showed 130 tons, it does not seem that greater allowances are either necessary or advisable.

7 The records in Table 1 cover 206 fits of diameters varying in size from 3.5 in. to 20 in., sufficient in range and number to demonstrate the correctness and value of the practice followed. All of these measurements and gage readings were taken by the same inspector, and as he was a thoroughly reliable man, I am satisfied that they are correct. The records are all of fits made on electric generators and motors.

8 The table shows the diameter of the shaft, the diameter of the bore, the length of the seat, the diameter of the hub, the material of which the hub is made, the allowance (the difference between the diameter of the shaft and the diameter of the bore of the hub into which the shaft is pressed), the pressure in tons required to force the shaft in, the maximum tension stress in the bore in pounds per square inch, the radial pressure on the surface of the shaft in pounds per square inch, and the coefficient of friction. These figures are given as a record of actual experience on sizes between the diameters shown. They are not claimed to represent correct practice beyond these dimensions.

9 In Table 1 the last three columns were figured from formulae developed by Prof. A. Morley and published in Engineering, August 11, 1911. In these formulae

R_1 = outer radius of hub
R_2 = inner radius of hub = radius of shaft after fitting
$A = R_1 - R_2$ = thickness of hub wall
$D = 2R_2$ = diameter of shaft
p_2 = radial compressive stress in lb. per sq. in. at radius R_2
f_t = hoop tension per sq. in. at radius R_2
J = excess in original diameret of shaft over that of bore of hub = allowance

[1] P. 1173.

E = Young's modulus for shaft material, assumed 30,000,000
E_1 = Young's modulus for hub material, assumed 15,000,000
} thus $E = 2E_1$

$\frac{1}{m}$ = Poisson's ratio for shaft material
$\frac{1}{m_1}$ = Poisson's ratio for hub material
} assumed $m = m_1 = 4$

Total tension stress at bore of hub

$$f_t = \frac{\frac{J}{D} \times E}{\left\{\left(\frac{m-1}{m} + \frac{1}{m_1} + \frac{E}{E_1}\right)\frac{R_1^2 - R_2^2}{R_1^2 + R_2^2} + \frac{E}{E_1}\right\}}$$

Normal pressure on surface of shaft

$$P_2 = \frac{\frac{J}{D} - \frac{f_t}{E_1}}{\frac{m-1}{m\,E} + \frac{1}{m_1\,E_1}}$$

Coefficient of friction

$$\mu = \frac{P}{P_2}$$

where

P_2 = total normal pressure in tons
P = pressure in tons required to force shaft into hub

EXAMPLE RECORD NO. 84

Cast-iron hub on steel shaft $D = 6.0025$ in., $J = 0.0025$ in., length of hub $l = 7$ in., thickness of hub $t = 3\frac{5}{8}$ in. Assuming $m = m_1 = 4$ and $E = 2E_1 = 30{,}000{,}000$, then

Max. tension stress $f_t = \dfrac{\frac{0.0025}{6} \times 30{,}000{,}000}{\left(\frac{3}{4} + \frac{1}{4} \times 2\right)\frac{44-9}{44+9} + 2} = 4425$ lb. per sq. in.

Radial pressure $p_2 = \dfrac{\frac{0.0025}{6} - \frac{4425}{15{,}000{,}000}}{\frac{3}{4 \times 30{,}000{,}000} + \frac{1}{4 \times 15{,}000{,}000}} = 2920$ lb. per sq. in.

$$\text{Coefficient of friction} = \frac{40}{\frac{\pi \times 6 \times 7 \times 2920}{2000}} = 0.207$$

TABLE 1 DATA AND CALCULATIONS ON PRESSED FITS

Number of Record	Diameter of Shaft, In.	Diameter of Bore, In.	Length of Seat, In.	Diameter of Hub, In.	Material in Hub	Allowance, In.	Pressure, Tons	Maximum Tension Stress of Bore, Lb. per Sq. In.	Radial Pressure on Surface of Shaft, Lb. per Sq. In.	Coefficient of Friction
1	3.504	3.500	6	5	Steel	0.004	30	25520	8680	0.105
2	3.504	3.500	6	5	Steel	0.004	45	25520	8680	0.157
3	3.504	3.500	6	5	Steel	0.004	45	25520	8680	0.157
4	3.503	3.500	6	5	Steel	0.003	50	19185	6525	0.233
5	3.504	3.500	6	4½	Steel	0.004	30	27360	6840	0.133
6	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
7	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
8	4.004	4.000	6	6¼	Steel	0.004	40	21125	8875	0.120
9	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
10	4.004	4.000	6	6¼	Steel	0.004	40	21125	8875	0.120
11	4.003	4.000	8	5½	Steel	0.003	30	17175	5325	0.112
12	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
13	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
14	4.004	4.000	6	6¼	Steel	0.004	45	21125	8875	0.134
15	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
16	4.004	4.000	6	6¼	Steel	0.004	33	21125	8875	0.0985
17	4.004	4.000	6	6¼	Steel	0.004	35	21125	8875	0.104
18	4.004	4.000	8	5½	Steel	0.004	40	22900	7100	0.112
19	4.004	4.000	6	7¼	Steel	0.004	50	19545	10456	0.127
20	4.004	4.000	6	6¼	Steel	0.004	45	21125	8875	0.103
21	4.004	4.000	6	6¼	Steel	0.004	50	21125	8875	0.149
22	4.004	4.000	6	6¼	Steel	0.004	50	21125	8875	0.149
23	4.004	4.000	6	6¼	Steel	0.004	45	21125	8875	0.103
24	4.004	4.000	6	6¼	Steel	0.004	45	21125	8875	0.103
25	4.054	4.051	6	6¼	Steel	0.003	40	15915	6286	0.153

26	4.054	4.051	6	6¼	Steel	0.003	40	15915	6286	0.153
27	4.505	4.500	8	6½	Steel	0.005	60	24665	8665	0.122
28	4.505	4.500	8	6½	Steel	0.005	50	24665	8665	0.102
29	4.5035	4.500	8	6½	Steel	0.0035	45	17285	6050	0.131
30	4.505	4.503	6½	5¾	Cast Iron	0.002	20	5750	1455	0.3
31	4.503	4.500	6	10	Cast Iron	0.003	30	7070	4690	0.151
32	4.503	4.500	6	10	Cast Iron	0.003	30	7070	4690	0.151
33	4.503	4.500	8	6½	Steel	0.003	40	14815	5185	0.136
34	4.503	4.500	8	6½	Steel	0.003	40	14815	5185	0.136
35	4.880	4.875	7	7½	Steel	0.005	48	21885	8865	0.101
36	4.880	4.875	6	7¼	Steel	0.005	45	22365	8385	0.117
37	4.880	4.875	6	7¼	Steel	0.005	45	22365	8385	0.117
38	4.880	4.875	7	7¼	Steel	0.005	60	22365	8385	0.143
39	4.880	4.875	7	7¼	Steel	0.005	45	22365	8385	0.107
40	4.880	4.874	6	7¼	Steel	0.006	67	26835	10064	0.145
41	4.880	4.875	7	8	Steel	0.005	40	21060	9690	0.077
42	4.880	4.875	6	7¼	Steel	0.005	50	22365	8385	0.130
43	4.880	4.875	6	7¼	Steel	0.005	50	22365	8385	0.130
44	4.880	4.876	7	7¼	Steel	0.004	40	17890	6710	0.111
45	4.880	4.875	6	7¼	Steel	0.005	50	22365	8385	0.130
46	4.880	4.875	7	8	Steel	0.005	55	21060	9690	0.106
47	4.880	4.875	6	7¼	Steel	0.005	45	22365	8385	0.117
48	4.880	4.875	6	7¼	Steel	0.005	45	22365	8385	0.117
49	4.880	4.875	6	7½	Steel	0.005	45	21885	8865	0.113
50	4.880	4.875	6	7½	Steel	0.005	45	21885	8865	0.113
51	4.880	4.875	6	7½	Steel	0.005	45	21885	8865	0.113
52	4.880	4.875	6	7½	Steel	0.005	45	21885	8865	0.113
53	4.880	4.875	7	8	Steel	0.005	55	21060	9690	0.106
54	4.880	4.875	6	7¼	Steel	0.005	40	22365	8385	0.104
55	4.880	4.875	6	7¼	Steel	0.005	50	22365	8385	0.130

TABLE 1—*Continued*

Number of Record	Diameter of Shaft, In.	Diameter of Bore, In.	Length of Seat, In.	Diameter of Hub, In.	Material in Hub	Allowance, In.	Pressure, Tons	Maximum Tension Stress of Bore, Lb. per Sq. In.	Radial Pressure on Surface of Shaft, Lb. per Sq. In.	Coefficient of Friction
56	4.880	4.875	7	8	Steel	0.005	50	21060	9690	0.096
57	5.003	5.000	7¾	10	Cast Iron	0.003	25	6545	3930	0.105
58	5.003	5.000	8	10	Cast Iron	0.003	20	6545	3930	0.081
59	5.002	5.000	5½	7¾	Steel	0.002	50	8500	3500	0.330
60	5.440	5.437	9	13⅜	Cast Iron	0.003	25	5730	4055	0.0806
61	5.440	5.437	9	13⅜	Cast Iron	0.003	25	5730	4055	0.0806
62	5.502	5.500	8	13	Cast Iron	0.002	22	3800	2650	0.120
63	5.502	5.500	8½	13	Cast Iron	0.002	25	3800	2650	0.128
64	5.630	5.625	7	13	Cast Iron	0.005	30	9340	6390	0.076
65	5.630	5.625	7½	8¼	Steel	0.005	40	19550	7115	0.085
66	5.629	5.625	8¼	8¼	Steel	0.004	65	15640	5695	0.207
67	5.630	5.625	7½	8½	Steel	0.005	65	19185	7480	0.131
68	5.630	5.625	7	8	Steel	0.005	45	19900	6765	0.1075
69	5.630	5.625	7	8¼	Steel	0.005	65	19550	7115	0.148
70	5.630	5.625	6½	8¼	Steel	0.005	65	19550	7115	0.159
71	5.630	5.625	7	8¼	Steel	0.005	65	19535	7115	0.147
72	5.630	5.625	7	8½	Steel	0.005	55	19185	7480	0.119
73	5.630	5.625	7	9¼	Steel	0.005	48	18260	8405	0.092
74	5.630	5.625	7½	8½	Steel	0.005	50	19185	9480	0.101
75	5.630	5.625	7	8¼	Steel	0.005	55	19535	7115	0.125
76	5.630	5.625	8	8	Steel	0.005	55	20000	665	0.1185
77	5.7525	5.750	8	12¾	Cast Iron	0.0025	18	4610	3060	0.081
78	5.752	5.750	8	12¾	Cast Iron	0.002	20	3690	2375	0.117
79	6.005	6.000	8	9	Steel	0.005	70	18055	6945	0.134
80	6.002	6.000	8	9	Steel	0.002	55	7220	2780	0.262

81	6.003	6.000	7¾	13¾	Cast Iron	0.003	30	5265	3575	0.115
82	6.005	6.000	8	9	Cast Iron	0.005	30	10485	3225	0.123
83	6.003	6.000	8	14½	Cast Iron	0.003	40	5200	3680	0.144
84	6.0025	6.000	7	13¼	Cast Iron	0.0025	40	4425	2920	0.207
85	6.0025	6.000	8	14½	Cast Iron	0.0025	38	4425	2920	0.173
86	6.130	6.125	7	8¼	Steel	0.005	65	19065	5475	0.176
87	6.253	6.250	9	11½	Steel	0.003	60	19065	5475	0.134
88	6.253	6.250	9	11½	Steel	0.003	65	9320	5080	0.145
89	6.253	6.250	9	11½	Steel	0.003	65	9320	5080	0.145
90	6.2735	6.273	9	11½	Steel	0.0005	15	1550	8401	0.20
91	6.5025	6.500	8	21¾	Cast Iron	0.0025	40	3790	3170	0.155
92	6.503	6.500	8	14¾	Cast Iron	0.003	40	4871	3280	0.149
93	6.502	6.500	8	14¾	Cast Iron	0.002	38	3245	2190	0.213
94	6.503	6.500	6	12	Cast Iron	0.003	40	5160	2835	0.23
95	6.503	6.500	8	13½	Cast Iron	0.003	35	4980	3110	0.134
96	6.502	6.500	8	13	Cast Iron	0.002	25	3355	2115	0.152
97	6.503	6.500	8	11¼	Steel	0.003	90	9220	4610	0.24
98	6.5025	6.500	8	14¾	Cast Iron	0.0025	25	4060	2735	0.112
99	6.503	6.500	8	14¾	Cast Iron	0.003	35	4800	3395	0.126
100	6.502	6.500	12	10	Cast Iron	0.002	50	3680	1495	0.275
101	6.610	6.605	11	14	Steel	0.003	60	8000	5620	0.094
102	6.939	6.937	7¾	13	Cast Iron	0.002	15	3210	1785	0.1
103	6.939	6.937	8	11	Cast Iron	0.002	17	3410	1465	0.133
104	7.002	7.000	10	12	Steel	0.002	75	5730	2820	0.242
105	7.002	7.000	10	12	Steel	0.002	80	5730	2820	0.268
106	7.003	7.000	10	12½	Steel	0.003	90	8325	4515	0.181
107	7.002	7.000	9	17	Cast Iron	0.002	50	2965	2110	0.24
108	7.003	7.000	10	13	Steel	0.003	85	8285	4615	0.168
109	7.003	7.000	10	13	Steel	0.003	80	8285	4615	0.158
110	7.003	7.000	9	16¾	Cast Iron	0.003	40	4465	3135	0.129

TABLE 1—*Continued*

Number of Record	Diameter of Shaft, In.	Diameter of Bore, In.	Length of Seat, In.	Diameter of Hub, In.	Material in Hub	Allowance, In.	Pressure, Tons	Maximum Tension Stress of Bore, Lb. per Sq. In.	Radial Pressure on Surface of Shaft, Lb. per Sq. In.	Coefficient of Friction
111	7.002	7.000	10	12	Steel	0.002	95	5730	2820	0.307
112	7.003	7.000	8	12¾	Cast Iron	0.003	35	4815	2600	0.153
113	7.003	7.000	10	13	Steel	0.003	50	8285	4615	0.0985
114	7.0035	7.000	8	14¾	Cast Iron	0.0035	45	5375	3400	0.12
115	7.003	7.000	9	17	Cast Iron	0.003	50	4450	3160	0.18
116	7.003	7.000	8	12	Steel	0.003	100	8605	4235	0.269
117	7.034	7.031	8	10½	Steel	0.003	75	9260	3520	0.262
118	7.034	7.031	8	10½	Steel	0.003	35	9260	3520	0.113
119	7.1895	7.187	7	13	Cast Iron	0.0025	25	3915	2085	0.152
120	7.2525	7.2495	9	16¾	Cast Iron	0.003	35	4350	2475	0.115
121	7.437	7.435	7½	11	Cast Iron	0.002	25	3275	1220	0.234
122	7.4395	7.437	8	13	Cast Iron	0.0025	25	3810	1970	0.136
123	7.502	7.499	8	12¾	Cast Iron	0.003	55	4605	2230	0.238
124	7.5025	7.500	8	13	Cast Iron	0.0025	35	3810	1905	0.194
125	7.5027	7.500	8	14½	Cast Iron	0.0027	20	3970	2290	0.0925
126	7.5029	7.501	8	25½	Cast Iron	0.0019	15	2460	2145	0.074
127	7.534	7.531	10	12	Steel	0.003	50	8320	3620	0.117
128	8.002	8.000	9½	13¾	Steel	0.002	60	5015	2485	0.202
129	8.002	8.000	9½	13¾	Steel	0.002	60	5015	2485	0.202
130	8.002	8.000	9½	13¾	Steel	0.002	60	5015	2485	0.202
131	8.002	8.000	16	14	Steel	0.002	110	4975	2525	0.217
132	8.002	8.000	9½	13¾	Steel	0.002	80	5015	2485	0.27
133	8.002	8.000	9½	13¾	Steel	0.002	85	5015	2485	0.286
134	8.002	8.000	9½	13¾	Steel	0.002	75	5015	2485	0.253
135	8.002	8.000	9½	13¾	Steel	0.002	80	5015	2485	0.27

135	8.002	8.000	9½	13¾	Steel	0.002	80	5015	2155	0.317
136	8.002	8.000	9	13½	Steel	0.002	80	5065	2435	0.318
137	8.003	8.000	9	17	Cast Iron	0.003	50	4025	2565	0.173
138	8.4395	8.4375	7	11	Cast Iron	0.002	25	3060	795	0.34
139	8.4395	8.437	8	11	Cast Iron	0.0025	18	3820	833	0.205
140	8.440	8.4375	8	11	Cast Iron	0.0025	15	3820	833	0.17
141	8.503	8.500	8	14¾	Cast Iron	0.003	35	4035	2015	0.162
142	8.503	8.500	8	14½	Cast Iron	0.003	45	4055	1980	0.212
143	8.503	8.500	9	15	Cast Iron	0.003	40	3815	2370	0.141
144	8.503	8.500	8	14¾	Cast Iron	0.003	45	4435	2020	0.208
145	8.5025	8.500	6½	15	Cast Iron	0.0025	30	3000	2255	0.154
146	8.505	8.5015	8	15	Cast Iron	0.0045	45	6005	3085	0.136
147	8.507	8.504	9	11	Cast Iron	0.003	40	4565	1145	0.292
148	8.564	8.562	14	13½	Cast Iron	0.002	30	2765	848	0.1875
149	8.939	8.937	8	13	Cast Iron	0.002	18	2860	762	0.211
150	8.939	8.937	8	13	Cast Iron	0.002	20	2860	762	0.234
151	8.939	8.937	8	13	Cast Iron	0.002	22	2860	762	0.257
152	9.002	8.999	12	20½	Cast Iron	0.003	65	3515	2375	0.161
153	9.002	8.999	12	20½	Cast Iron	0.003	65	3515	2375	0.161
154	9.0025	8.999	12	20½	Cast Iron	0.0035	75	4100	2375	0.159
155	9.0025	8.999	12	20½	Cast Iron	0.0035	75	4100	2375	0.159
156	9.0015	8.9995	9	16¾	Cast Iron	0.002	22	2480	1370	0.126
157	9.002	9.000	10	14	Steel	0.002	80	4710	1955	0.29
158	9.002	9.000	10	14	Steel	0.002	75	4710	1955	0.272
159	9.003	9.000	12	20¾	Cast Iron	0.003	70	3500	2395	0.171
160	9.003	9.000	12	20¾	Cast Iron	0.003	70	3500	2395	0.171
161	9.003	9.000	12	21	Cast Iron	0.003	70	3495	2410	0.171
162	9.003	9.000	12	20¾	Cast Iron	0.003	70	3500	2395	0.171
163	9.002	9.000	13	20½	Cast Iron	0.002	75	2345	1585	0.257
164	9.003	9.000	12	20¾	Cast Iron	0.003	90	3500	2395	0.22
165	9.003	9.000	12	14¾	Cast Iron	0.003	85	3890	1775	0.298

TABLE 1—*Continued*

Number of Record	Diameter of Shaft, In.	Diameter of Bore, In.	Length of Seat, In.	Diameter of Hub, In.	Material in Hub	Allowance, In.	Pressure, Tons	Maximum Tension Stress of Bore, Lb. per Sq. In.	Radial Pressure on Surface of Shaft, Lb. per Sq. In.	Coefficient of Friction
166	9.003	9.000	10	18⅜	Steel	0.003	100	6200	3795	0.187
167	9.003	9.000	10	18⅜	Steel	0.003	80	6200	3795	0.149
168	9.003	9.000	9	17	Cast Iron	0.003	45	3700	2080	0.17
169	9.003	9.000	9	17	Cast Iron	0.003	50	3700	2080	0.189
170	9.939	9.937	7½	13	Cast Iron	0.002	25	2745	720	0.295
171	9.9998	9.996	9	16¾	Cast Iron	0.0038	60	4400	2080	0.204
172	10.003	10.000	9	16¾	Cast Iron	0.003	40	3495	1640	0.172
173	10.004	10.000	12	21	Cast Iron	0.004	90	4205	2715	0.176
174	10.0035	10.000	14	21	Cast Iron	0.0035	80	3765	2375	0.153
175	10.002	10.000	12	18	Steel	0.002	55	3925	2475	0.128
176	10.502	10.500	8	13	Cast Iron	0.002	16	2505	550	0.22
177	11.002	11.000	12⅝	18	Steel	0.002	70	3750	1705	0.189
178	11.002	11.000	12⅝	18	Steel	0.002	80	2750	1705	0.216
179	11.005	10.9997	14	20¾	Cast Iron	0.053	38	5350	3005	0.0525
180	11.002	11.000	12¾	18	Steel	0.002	85	3750	1705	0.24
181	11.002	11.000	13½	18	Steel	0.002	90	3750	1705	0.227
182	11.002	11.000	13	18	Steel	0.002	90	3750	1705	0.235
183	11.002	11.000	13	18	Steel	0.002	70	2750	1705	0.183
184	11.002	11.000	12¾	18	Steel	0.002	90	3750	1705	0.24
185	11.002	11.000	13	18	Steel	0.002	100	3750	1705	0.261
186	11.0025	11.000	10	17½	Cast Iron	0.0025	50	2680	1160	0.25
187	11.0035	11.000	10	17½	Cast Iron	0.0035	60	2755	1625	0.214
188	11.064	11.062	12	18¾	Cast Iron	0.002	48	2100	975	0.236
189	12.004	12.000	12	20¾	Cast Iron	0.004	130	3815	1895	0.302
190	12.003	12.000	13	20½	Cast Iron	0.003	70	2875	1405	0.204

191	12.004	12.000	13	21	Cast Iron	0.004	78	3795	1930	0.165
192	13.0045	13.002	13	21½	Cast Iron	0.0025	100	2235	1035	0.362
193	13.003	13.000	14	22	Cast Iron	0.003	85	2660	1265	0.235
194	13.0045	13.000	12	22	Cast Iron	0.0045	90	4000	1905	0.193
195	13.0045	13.000	12	22	Cast Iron	0.0045	100	4000	1905	0.213
196	13.003	13.000	12	25½	Cast Iron	0.003	70	2530	1470	0.195
197	13.004	13.000	13	26	Cast Iron	0.004	100	3355	2015	0.187
198	13.0035	13.000	13	22	Cast Iron	0.0035	110	3105	1490	0.252
199	13.003	13.000	12¾	21	Steel	0.003	125	4790	2130	0.225
200	14.033	14.031	14	21	Steel	0.003	150	4785	1845	0.264
201	14.033	14.031	14	21	Steel	0.002	100	3075	1185	0.274
202	14.5035	14.500	13	25½	Cast Iron	0.0035	100	2720	1430	0.235
203	16.004	16.000	14	25½	Cast Iron	0.004	120	2865	1415	0.241
204	20.002	20.000	20	28⅞	Steel	0.002	160	2220	780	0.327
205	20.0025	19.999	20	29	Steel	0.0026	140	2880	1020	0.218
206	20.0025	19.999	20	29	Steel	0.0026	140	2880	1020	0.218

CONTINUOUS MANUFACTURING BY PLACING MACHINES IN ACCORDANCE WITH SEQUENCE OF OPERATIONS

By Oscar C. Bornholt

ABSTRACT OF PAPER

Continuous manufacturing appeals to all manufacturers who have a product requirement large enough to carry out the idea. The paper outlines such an arrangement of machines in use by a manufacturing plant that has been phenomenally successful. Here it is shown not to be necessary to impair the best sequence of operations taking into consideration the gaging points, etc., as would be the case if the operations had to be outlined to accommodate the classification group of machines to prevent the passing to and from the different departments of like machines. An illustration of unit production is given in the manufacture of a universal joint which is familiar to all automobile manufacturers, and also by taking the first few operations on an automobile block cylinder for an example. The two ways of manufacturing are compared, showing in one case the excessive expense of trucking. Cylinders of course are especially adapted to manufacture with machines placed in accordance with sequence of operations, but small forgings can also be produced in quantities much cheaper in this manner as shown in the case of rods. The closing remarks touch upon the raw stock necessary for manufacturing, which is less in the shop where machines are placed in accordance with sequence of operations.

CONTINUOUS MANUFACTURING BY PLACING MACHINES IN ACCORDANCE WITH SEQUENCE OF OPERATIONS

By Oscar C. Bornholt, Detroit, Mich.

Member of the Society

In any manufacturing enterprise the cost of production is very important, and a great deal of money can be wasted if proper facilities are not provided. Even though a plant has the very latest and most efficient machines and fixtures, money can be unnecessarily spent in trucking. Trucking in the machine shop is always looked upon as an unnecessary expense and yet many plants have a large trucking expense. This involves the question whether the manufacturing machines in a machine shop should be laid out in accordance with the sequence of operation, or whether they should be grouped according to the class of operation requiring like machines, such as placing together all milling machines, all drill presses, etc.

2 I will endeavor to show that the arranging of machines according to sequence of operation, as practised by the Ford Motor Company, has a great advantage over the classified machine grouping. In the former case the operations on any part to be manufactured can be outlined according to the best advantage in manufacturing the part. It might be well, on account of the nature of the part to be manufactured, to have a milling operation first, then drilling, then milling, and it would not make any difference what sort of machine followed on each operation. But if the latter arrangement of grouping were decided upon, the operations would have to be arranged so that like operations on the same part would follow each other. For illustration, a milling operation should not come between two drilling operations so that the part would have to be trucked to the drill department first, then to the milling depart-

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ment, and then back to the drill department. Trucking is expensive and all its labor is non-productive.

3 The trucking item is immense in a large plant when the machines are arranged according to class, as all parts have to be trucked many times before they are finished. When machines are placed according to sequence of operation there is no trucking of parts after the first operation is started, as each operator lays the part down in such a place and manner as to allow the next operator to pick it up and perform his operation, and so on. When finished, the part goes either to the finished stock room or assembling department.

4 A good example of continuous manufacturing is found in the making of tin cans. The body of the can is started at one side of the building in a machine for forming it; it next goes to the body-soldering machine and then to the header which has been fed with the two heads; when the heads are on, the can travels upstairs to have the heads soldered. The first machine sets the pace and the operators of the other machines must keep their machines moving at a similar rate so that the stock will not run short or accumulate. This arrangement therefore helps to increase production.

5 At the Ford plant the machines are arranged very much like the tin-can machines. All parts of a unit assembly are made on machines that are so laid out that the last operations bring them near together. This applies of course only to the large pieces, but all parts of a unit are made in one department under a foreman.

6 Automatic screw machine parts are made in an automatic screw machine department where one man runs several machines. There would be no object or advantage in placing automatic machines among semi-automatic and manual operative machines. It is well understood that there are many operations that require more than one machine, but they are placed to draw from the one machine doing the previous operation. This gives the effect of the whole operation being done on one machine.

7 The operations have to be gone over carefully to ascertain the capacity either by previous records or by good judgment. In many operations more than one machine will be required, but there will not be work enough for two. Although the first cost may seem high it is a great saving to have a machine for every operation and enough of them.

8 The carbonizing and hardening operations are awkward to have in the machine shop, but at the Ford plant a cyaniding and hardening department is placed in the middle of the machine shop.

It is glassed in and thoroughly ventilated with a separate system to carry off the fumes from the cyanide pots. All parts to be cyanided and hardened are led up to this department and thus trucking to a separately located building is avoided. This would amount to several hundred tons of material a day.

9 On account of the great amount of heat generated, the heat-treating and carbonizing departments had to be placed in a separate building where the walls could be opened 60 per cent. Brazing is done in the machine shop, just before the parts reach the assembling department. All shop furnaces are operated with low-pressure air (1½ lb.) and city gas.

10 As an illustration of unit production, I will take the universal joint which has only four pieces and four rivets. Assuming a production of 80 pieces per hour is required, it would take

80 universal joint knuckles (male)
80 universal joint knuckles (female)
160 universal joint knuckle rings (halves)
320 rivets

11 The universal joint knuckle (male) has six operations, as given in Table 1.

TABLE 1 OPERATIONS ON THE UNIVERSAL JOINT KNUCKLE

Operation	Work	Machines Required	Capacity, per Hour
First	Mill square end	2 Millers	40
Second	Turn to size, 3⅛ in. diameter	1 Lathe	80
Third	Turn trunnion ends	2 Duplex drills	40
Fourth	Mill ends, shoulder clearances	2 Millers	60
Fifth	File	Bench for filing	..
Sixth	Harden	Furnace in the hardening room in the machine shop; knuckle to be returned to assemble	..

12 The operations on the universal joint knuckle (female) are similar. The rings are broached, and then ground on a disc grinder, which is placed in the machine shop. The grinder is equipped with a dust exhauster and collector so that no emery dust flies to other machines.

13 After all the parts are completed, they are led up to an assembler who also rivets them. They are then inspected and sent to the finished stock room or the assembling department, usually

the latter, since the production of the whole shop must be balanced up.

14 At the Ford plant, the cylinders are trucked from the foundry to the border of the aisle, down which are located the machines which perform the first operation. They are light enough to be carried by the operators to their machines while the latter are mak-

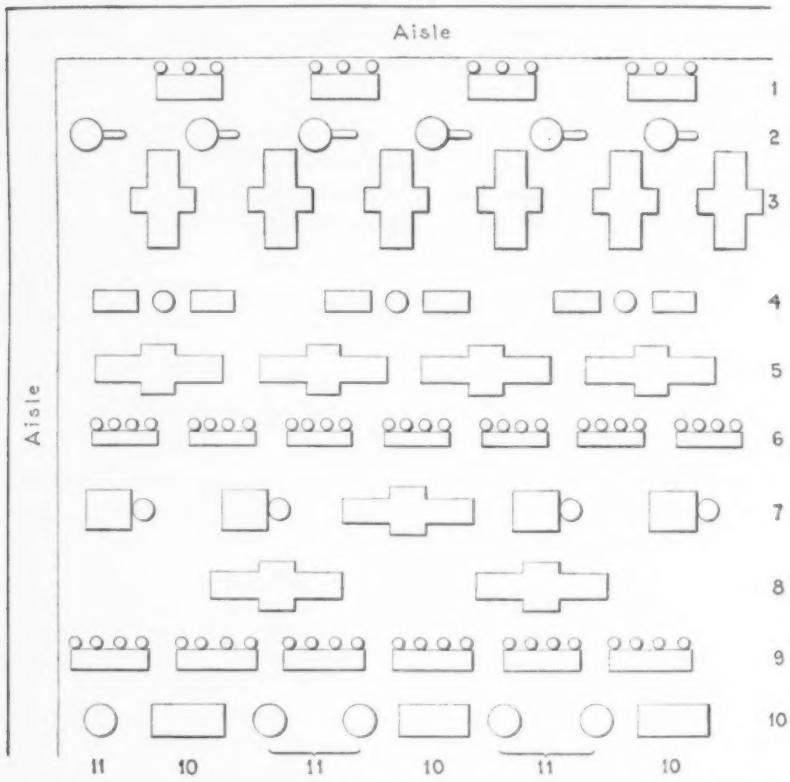

FIG. 1 SEQUENCE ARRANGEMENT OF MACHINES IN CYLINDER DEPARTMENT

ing cuts. The cylinders move to each successive machine until they land in the assembling department which borders the cylinder department. All cast-iron parts are made in the same way; some of the small parts have to be trucked to the assembling department, but in rare cases only. The trucking that is done at the Ford plant is taken care of by many two-ton monorail traveling hoists operated by electricity and forming a small railway system.

15 An illustration of the cylinder department for the first few operations is given in Fig. 1.

First operation—drill, tap and plug three cored holes

Second operation—spot face and inspect. This is one of the most important operations on the cylinder, since it detects any defect that might have occurred in the foundry. It also finishes spots to enable the placing of the cylinder in the jigs quickly and accurately. Many cylinders are thus saved in this jig because it is arranged to adjust the cylinder to ensure its being finished all over.

Third operation—mill bottom

Fourth operation—drill six main bearing bolt holes and ream two of the holes for use in gaging or jigging. The drilling is done in a six-spindle inverted drill press and the two holes are reamed in a single-spindle drill press.

Fifth operation—mill top and sides

Sixth operation—bore cylinder barrel

Seventh operation—water test

Eighth operation—mill ends of cylinder

Ninth operation—finish ream barrel

Tenth operation—drill valve seat holes

Eleventh operation—drill and ream valve-stem holes, etc., until the cylinder reaches the assembling department.

16 It may be of interest to compare the two ways of arranging machines for manufacturing by using the cylinder operations of various kinds: In placing the machines according to operations it is necessary only to truck the cylinder to the first operation and after the last, because it is quite necessary to stock a few cylinders ahead of assembling. If the cylinders were to be machined in departments consisting of like machines, it would be necessary to truck to and from each department. Considering 1000 cylinders a day and the cylinders weighing above 80 lb. each, it would total 80,000 lb. to each department.

17 Grouping the operations on the cylinder to see how many times it is handled in how many departments, there are: drilling, milling, lathe, testing, tapping, babbitting, back to drilling, and grinding. It would be conservative to estimate that the cylinder would have to be trucked about 12 times. On account of some operations it would have to return to a department in which it had already been, and would therefore be handled more times than there are departments.

18 Each handling will amount to 80,000 lb., or 40 tons, and 12 handlings will amount to 480 tons a day, while the total number of feet of movement for each cylinder will be at least 500. This makes 480 tons traveling 500 ft. at the probable rate of 180 ft. a min., which is about the gait of a man trucking. Assuming a man can truck 960 lb., or 12 cylinders, at the above rate of travel, and figuring the necessary time for loading and unloading as 10 minutes, it would

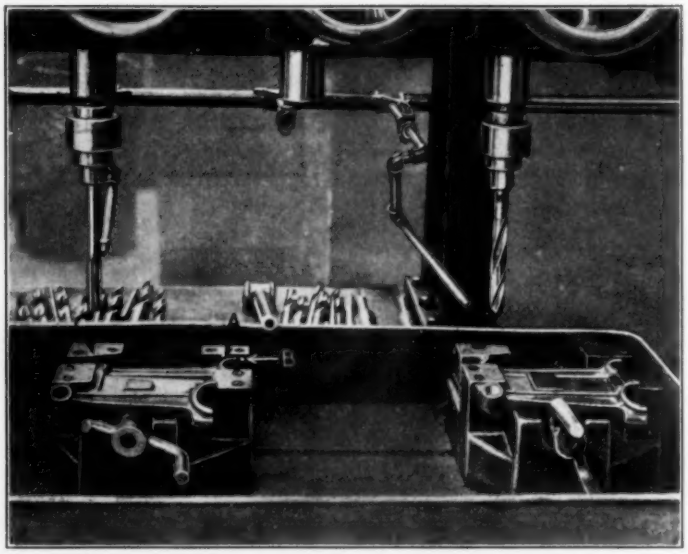

FIG. 2 DRILLING AND REAMING PISTON PIN HOLES

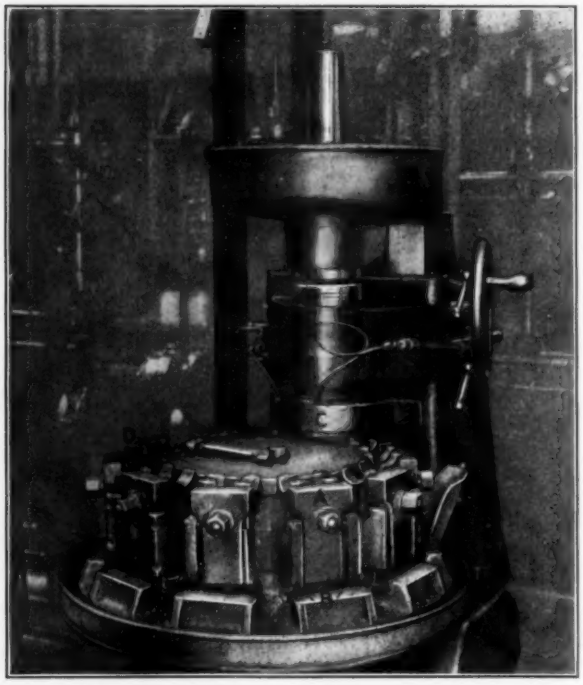

FIG. 3 CONTINUOUS MILLING OF CONNECTING ROD ENDS

require a force of 24 men with trucks to handle the 1000 cylinders per 10 hours.

19 While it may be claimed that the cylinder is especially adaptable to manufacture with machines placed in accordance with the sequence of operations, small forgings can also be produced in quantities much cheaper in the machine shop when the machines are placed in this way.

20 The machining of connecting rods shows how this system is applied where comparatively small forgings are used: These are brought in from the forging shops, and begin their passage down the row of machines which are arranged for the various operations. Nearly all of the machining operations consist of drilling, and the

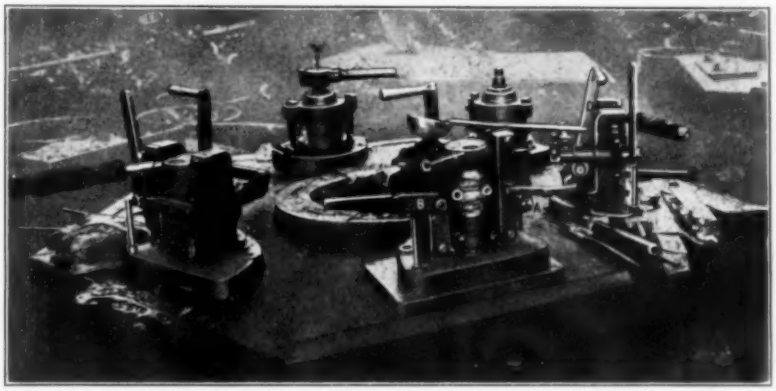

FIG. 4 ONE OF THE BABBITTING FURNACES FOR RODS AND BEARING CAPS

rods pass from one machine to the next, each being fitted to perform a specific operation. A typical view is shown in Fig. 2, where the wrist or piston pin hole is being drilled and reamed.

21 Adjoining this is a continuous milling machine shown in Fig. 3, the correct length being secured by having the piston pin hole slip over a suitable stud at the lower end of the fixture. The rods are held in pairs, as can be seen.

22 As soon as the connecting rods are ready to receive the babbitt, they have reached one of the babbitting furnaces, shown in Fig. 4, which is very near to the last machine. The particular furnace shown happens to be babbitting the caps for the bearings, but is exactly similar in detail to the one which babbitts the connecting rods themselves. After babbitting, the rods are bored; they are then complete and ready to go to the assembling department.

23 There is another advantage in placing the machines in ac-

cordance with the sequence of operations; even though some machines are not worked to their full capacity the amount invested in them is well paid for from the fact that it is not necessary to carry nearly so much stock as when the machines are grouped according to their classification. Each group or department alone would in that case need to have nearly as much raw stock to work with as is necessary with this method to operate the whole series of machines to complete the part.

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The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

In *The Journal* for May 1913 was printed an abstract of an article by Neumann on Processes in a Gas Producer from the Standpoint of the Second Law of Thermodynamics, in which the author held that there was a loss in heating value of the gas of between 10 and 30 per cent between the time the gas left the fuel bed and the time it reached the exhaust pipe. This statement has met with considerable scepticism both abroad and, judging from letters received at this office, in this country. Attention is therefore called to the abstract of the article of Hudler, in this issue, who holds that the results obtained by Neumann are true only for the very small producer with which the tests were made, and do not apply to producers of the normal commercial sizes. In connection with this the author gives what appears to be a firm foundation for the understanding of the higher efficiency of the large producer as compared with the small one. The difference between center gas and edge gas is also discussed, and the influence of their mutual proportion in the final product on its calorific value forcibly pointed out.

THIS MONTH'S ARTICLES

The Jaeger turbine-driven air pump shows how German designers are proceeding to solve the still unsettled problems connected with the construction of this class of machinery. In the same section are reported the proposed Russian rules for testing fans and compressors, interesting not only in themselves, but also on account of the attractiveness of the Russian market for American built air machinery. The illustrated article on cement machinery, while giving few constructional details, illustrates some of the types of German machinery exhibited at the last Exhibition of Building Trade in Leipzig. In the section Hydraulics is reported another installment of the article of Allievi on the theory of water hammer containing a full discussion of the characteristic of the conduit, and table of its possible numerical values. In the Recovery of Heat Losses in Explosion Engines the questions of how much of the heat of internal combustion may be commercially recovered and methods for accomplishing

it are fully discussed. The Blezinger producer is described in the same section.

As the volumes and speeds of transportation of the materials used in modern engineering increase, their measurement becomes both more difficult and more important. The difficult problem of measuring high-speed air blasts is claimed to be solved by the Morell anemotachometer described in the section Measuring Instruments, where also the Féry Thermo-electric direct-reading calorimetric bomb and a new process for making visible stream lines in liquids are described.

Particular attention is called to the section on Pumps in which the first article discusses the relation between the angle of coupling and ratio of piston areas in coupled double-acting twin-pumps, on one hand, to the dimensions of the flywheel, on the other; the second article contains a mathematical exposition of the theory of centrifugal water pumps, as a basis for a graphical method, to be reported in a future issue of *The Journal*. This permits of a predetermination of the characteristic curves of the pump from its design. Reasoning on the basis of the degree of diffusion, the author constructs a theory of water pumps fully analogous to that of water turbines. In the section Steam Engineering data on the use of Allagit for water purification are reported; natural and mechanical draft in steam plants are compared, the conclusion being that both have their own fields of application, and do not really compete: the blower is an auxiliary to, rather than substitute for, the smokestack. As to the latter, a new type is described, suitable chiefly for places where the stack has to be built very high. The new, grid or dissipator type, is claimed to produce practically smokeless combustion under conditions where an ordinary stack would emit black clouds.

ABSTRACTS OF ARTICLES

Air Machinery

JAEGER TURBINE-AIR-PUMP (*Jaegers Turbineluftpumpe*, A Förster, *Die Turbine*, vol. 9, no. 23, p. 412, September 5, 1913, 3 pp., 10 figs. *d*). The Jaeger centrifugal air pump belongs to the class of pumps working with an auxiliary liquid; it may be driven either by a high-speed electric motor, or by a steam turbine running at 1500 to 3000 r.p.m. In that case the turbine receives live steam and gives its exhaust steam to the low-pressure stage of the main turbine, so that the pump turbine can be regulated for any speed of rotation, and is entirely independent of electric energy. The air pump, cooling water pump and condenser pump may often be conveniently assembled in one aggregate. The water enters through the admission pipe *a* (Fig. 1A) and after passing through the regulating valve *c*, is thrown by the centrifugal wheel *d* in thin jets into the circular nozzle *e* surrounding the wheel. As shown in Fig. 1B these jets form in the circular nozzle spiral water bands *g*, between which is compressed the air coming in through opening *f*. This air is compressed by being driven forward until it passes into the pressure piping together with the water. The centrifugal wheel is easily accessible; small cross-sections subject to being clogged up are carefully avoided. The bands of water are extremely thin, there being no excessively narrow cross-sections either in the centrifugal wheel or in the circular nozzle, which decreases the amount of water used, and permits the use of comparatively dirty water. By means of the regulating valve *c* (Fig. 1A) the supply of auxiliary water, and thereby the output of the pump may be regulated at will. The graph in Fig. 1C shows the output of a pump of average size, where the weight of air delivered is plotted as a function of either partial pressure or partial vacuum.

CONCERNING THE DRAFT OF THE RULES FOR TESTING FANS AND COMPRESSORS (*Po povodu pravil dla ispytanya ventilatorof i kompressorof*, A. P. Hermann, *Zapiski Imperatorskava Russkava Tekhnicheskava Obshchestva*, vol. 47, nos. 6-7, June-July 1913, p. 161, 10 pp., 11 figs. *p*). A draft of rules for testing fans and compressors prepared by a special committee of the Second Russian Mining, Metallurgical and Machine Construction Convention. These rules are in the main based on the *Regeln* of the *Verein deutscher Ingenieure*. The Russian rules, however, contain also a chapter on Fundamental Elements of the Contract of Tests by which only such guarantees are admittted as can be verified by direct methods, and it is prescribed that for all such guarantees the method of verification must be stated in the contract, as well as the maximum deviation from the guaranteed figures; while the magnitude of these deviations is left to

the free agreement of the contracting parties, unless it is stated that the actual test values may be below the guaranteed values, no implied assumption to this effect may stand. For turbo-compressors the Russian rules introduce the use of characteristic curves, the respective passage reading as follows: "characteristic curves of compressors are used exclusively in testing turbo-compressors, mainly in testing stations. These curves express the functional relation between the pressure of a gas and the

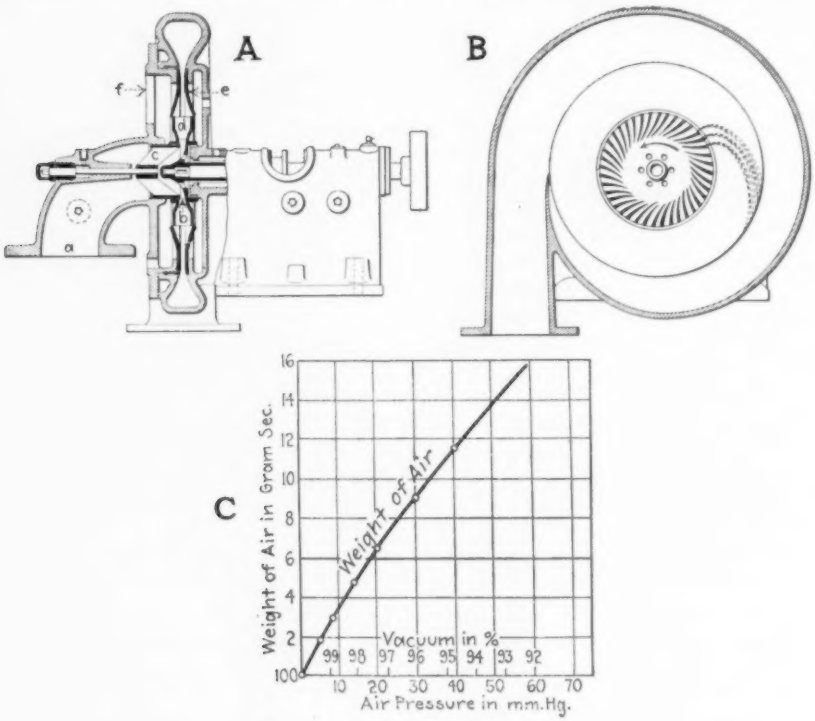

FIG. 1 JAEGER TURBINE AIR PUMP

volume delivered at different speeds of rotation, and are plotted together with the curves of equal isothermal efficiencies. Such curves give a clear picture of the conditions of work of a turbo-compressor where its efficiency varies between the lowest and highest permissible limits, as well as define the conditions of the most efficient work of the compressor."

Cement

CEMENT MACHINERY AT THE INTERNATIONAL EXHIBITION OF BUILDING TRADES IN LEIPZIG IN 1913 (*Zementverarbeitungsmaschinen auf der Internationalen Baufach-Ausstellung in Leipzig* 1913, C. Naske, *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 39, p. 1543, September 27, 1913, 2½ pp., 8 figs. *d*). Both hand and power driven machinery has been shown; to the latter belongs the Gaspary artificial stone making machine (Fig. 2 A)

which makes two bricks at a time, and has an output of 9000 bricks in 10 hours; another machine of the same company has an output twice as large. Fig. 2 B shows a sand and gravel washing machine in which counter current washing is combined with trough washing, this making it particularly suitable for handling mixed stuff like sand and gravel. Small hydraulic presses for making floor and wall tiles, as well as the tiles themselves, have been also exhibited. The Steinbrecher cement brick making machine (Fig. 2C) can make one or two bricks at a time. Its powerful lever with high leverage produce, with a mixture of 1 part cement to 3 parts sand, a perfectly water tight brick, which can be used without a protective layer of paint or cement. The parts subject to wear are made replaceable, the profile plate being of hardened steel. Fig. 2D shows the cement pipe stamping machine of the Royal Bavarian Mining Administration. The same concern exhibited the Kunz concrete and mortar mixing machine shown in Fig. 2E and F. This machine, with a capacity of 450 liters (15.75 cu. ft.) has an output of 150 cbm (say 5300 ft.) per day; it is provided with a device for hoisting the mix, which, as well as a winch, are driven by an electromotor forming part of the installation. Several other types of concrete mixing machines have been exhibited and are briefly described in the original article.

Hydraulics

THEORY OF THE WATER HAMMER (*Théorie du coup de bélier*, L. Allièvi. *Bulletin technique de la Suisse Romande*, vol. 39, nos. 11, 14, 15, pp. 121, 159, 171, June 10, July 25, August 10, 1913. Serial article, not finished. *tA*). Continuation of the abstracts published in *The Journal*, August 1913, p. 1287, and September 1913, p. 1434. The nature of the phenomena accompanying a variable motion of a liquid in a conduit and characterized by continual variations of velocity and pressure is evidently determined by the fact that these variations give rise to continual transformations of the kinetic energy of the liquid column into potential energy (elastic deformations) of the liquid and walls of the conduit, and vice versa. It appears therefore that the laws of these phenomena must be in direct relation with the quantities of energy, either kinetic or potential, contained at every instant in each section of the conduit. Since, however, system [9] (*The Journal*, September 1913, p. 1435), which is the analytical expression of these laws, relates to the data characterizing the conduit only through the intermediary of the characteristic ρ, it is to be expected that this characteristic, which fully defines the permanent operation of the conduit, is also closely related to the quantities of potential or kinetic energy contained in a unit of length of the conduit while the latter is operated under permanent conditions, and it can be shown that ρ can be expressed by half of the square root of the ratio between these two quantities of energy, or that

$$\rho = \frac{1}{2}\sqrt{\frac{W_o}{W}} \qquad [10]$$

where W_o is the quantity of kinetic energy contained, under normal operating conditions, in a unit of length of the conduit, i.e. the kinetic energy stored up in a unit of length of a column of liquid having velocity

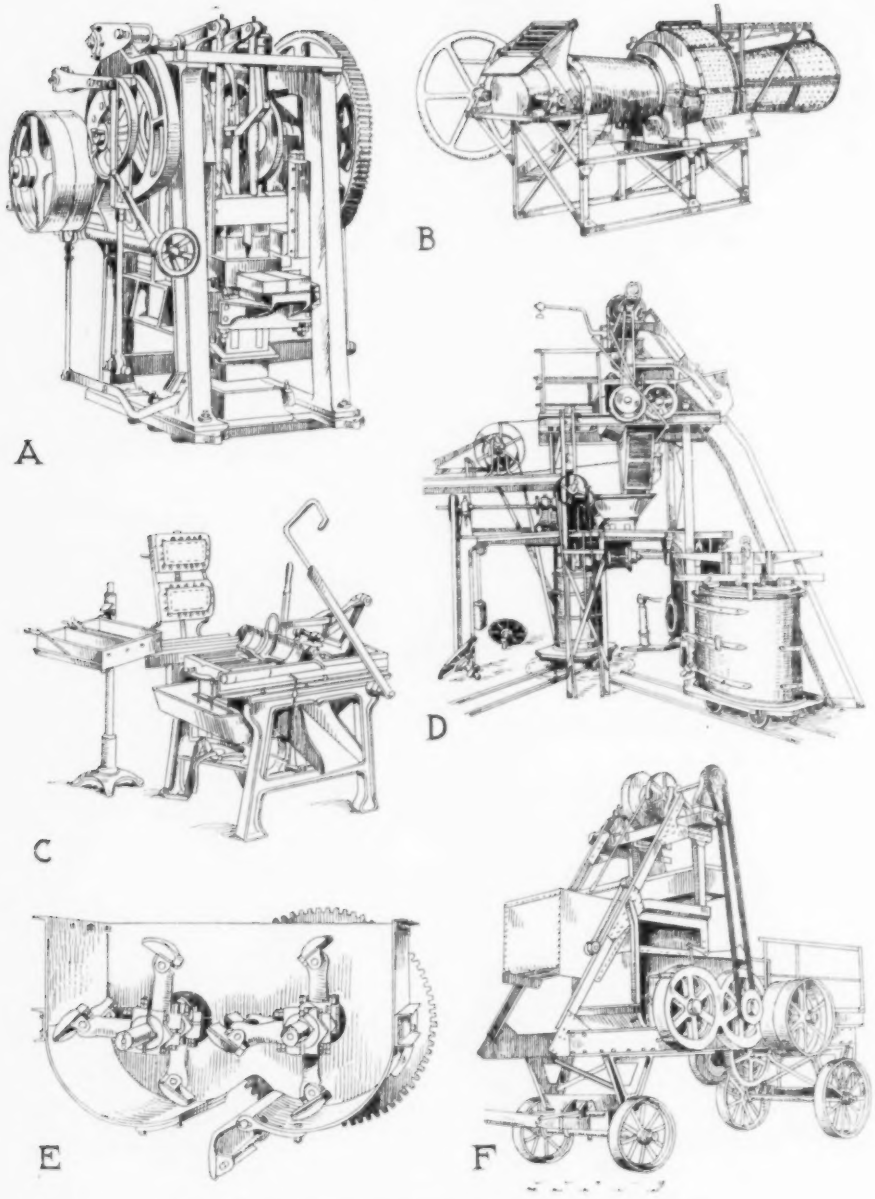

FIG. 2 GERMAN MACHINES USED IN THE CEMENT INDUSTRY

v_0; and W the quality of potential energy contained, also under normal operating conditions, in a unit of length of the conduit, i.e. the sum of the qualities of energy absorbed, first, by the elastic compression of a unit of length of the liquid column, and, next, by the elastic deformation of the walls of the conduit, within a unit of length of the latter. The next point is to determine the numerical limits between which the characteristic ρ may fluctuate in practical applications.

It has been previously shown (cp. *The Journal*, August 1913, p. 1287) that the velocity of propagation of variations of load along a conduit a varies from 600 to 700 m. for thin-walled pipes of large diameter, to 1200-1300 m. for thick-walled pipes of small diameter, while the normal velocity v_0 varies from 1.50 to 3.00 m./sec. To understand the numerical calculation of ρ, the following must be borne in mind: All the preceding formulae are based on the assumption that the velocity of propagation of variations a, and consequently the ratio $D:e$, are constant along the entire length of the conduit. This assumption is sufficiently exact in certain cases, e.g. with conduits, often very long, for water distribution in cities, but is seldom true in the case of feeds to hydraulic plants, which are of particular interest in this connection. The conduits of this character are inclined, in a vest majority of cases, so that the ratio $D:e$ (where e is the thickness calculated on the basis of the static load to which each section of the conduit is subjected) decreases from top to bottom of the conduit, while a decreases from bottom to top. In such a case an average value of a has to be used, such that, if the variations of pressure were transmitted at this average velocity along the conduit, the time occupied for making the entire length of conduit L would be $L:a$, equal to $\Sigma(l_x:a_x)$, which is the time actually occupied for making at the variable velocity a_x, the sum of the sections l_x forming the conduit of length L. It appears logical to use, in calculating ρ, the average value of a as defined above when a water hammer is considered of sufficient duration to permit the elasticity of the entire conduit to act; this would certainly happen in the case of the so-called counter blow, the duration of which considerably exceeds that of the phase $\mu = 2L:a$ of the direct blow. On the other hand, when direct-blow phenomena are considered, of duration inferior to μ, in the calculation of ρ, for a the value correcponding to the lowest section of the conduit must be taken. In general, however, the extreme limits between which a may vary are close enough to make the use of an average value of a possible in this calculation without materially affecting the exactness of the results.

The following calculation of a conduit having a constant slope is given here as an example of the application of this method. The thickness of the walls is calculated at each point, on the basis of the corresponding static load, for a constant ratio of work R.10^6 kg./m^2, this thickness being subsequently increased by a value, assumed to be proportional to the diameter, say, at the ratio of 0.0025 m. per meter. If therefore the static load in a section of abscissa x be designated by y_x, then

$$\frac{2e}{D} = \frac{1000 y_x}{R \cdot 10^6} + 0.005$$

Taking $R = 7$ kg./mm^2, and introducing the value of $2e:D$ into an equa-

tion of modified form of [1a] (cp. *The Journal*, August, p. 1287) the following expression for the velocity of propagation of variation a_x in the section of the conduit under consideration is obtained

$$a_x = 1425\sqrt{\frac{y_x+35}{y_x+180}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [11]$$

which is correct to a great degree of approximation. By means of this

TABLE 1 $y_x - a_x$ VALUES

y_x	a_x	y_x	a_x	y_x	a_x
0	628	90	974	350	1216
10	703	100	990	400	1236
20	747	120	1025	500	1266
30	792	140	1054	600	1287
40	834	160	1080	700	1305
50	865	180	1102	800	1318
60	897	200	1122	900	1329
70	924	250	1161	1000	1333
80	948	300	1192	1100	1346

TABLE 2 VALUES OF CHARACTERISTIC ρ FOR DIFFERENT CONDITIONS OF OPERATION

y_0	a	ρ for Velocity		y_0	a	ρ for Velocity	
		$v_0 = 1.50$ m	$v_0 = 3.00$ m			$v_0 = 1.50$ m	$v_0 = 3.00$ m
1000	1184	0.09	0.18	120	861	0.55	1.10
800	1153	0.10	0.21	100	837	0.64	1.28
600	1110	0.14	0.28	80	809	0.77	1.55
500	1082	0.16	0.33	60	777	0.99	1.98
400	1046	0.20	0.40	40	739	1.41	2.83
300	1000	0.25	0.51	30	717	1.83	3.66
200	936	0.36	0.72	20	694	2.65	5.30
140	883	0.48	0.97	10	665	5.09	10.18

formula, Table 1 has been obtained. If the values of this table be substituted in the expression $L:a = \Sigma\ (l_x:a_x)$, average values of a will be obtained for conduits at constant slope for heads between 1000 and 10 meters (3280 to 32.8 ft.). These results are tabulated in Table 2 which contains also the values of the characteristic ρ corresponding to those heads and to the extreme normal velocities $v_0 = 1.50$m/sec. (4.92 ft./sec.) and 3.00 m/sec. (9.84 ft./sec.). This table shows that practically ρ varies between 0.10 and 10. In the next abstract will be shown a simple method of representing these systems of values graphically.

Internal Combustion Engines

ON THE RECOVERY OF HEAT LOST IN EXPLOSION ENGINES (*De l'utilisation des chaleurs perdues des moteurs à explosion*, G. Debesson, *La Technique moderne*, vol. 7, no. 7, p. 209, October 1, 1913. 5 pp., *pt*). The author discusses the question in how far the heat losses of internal-combustion engines admit of industrial recovery. There are certain losses which cannot be so recovered. Thus, in a gas engine even very well constructed, there are losses, about 5 per cent, due to incomplete combustion, while in poorer built engines there may also be losses due to improper regulation of the air admission. In addition, even in the best built engines there are leaks in the valves or past the piston, or due to pre-escape of gases, these losses amounting to, in good engines, about 5 per cent more. Further a certain amount of heat is lost through radiation from the piping and various organs of the engine, and, while some of it may be recovered by proper ventilation of the room, there will inevitably be about 5 per cent more losses from this source, thus making up a total of about 15 per cent of the initial heat value of the gas or liquid used in the engine (working fluid). With producer gas there will be further losses between the gas producer and the engine; the cooling of the gas involves considerable losses which cannot be commercially recovered because the water used for this purpose is not heated high enough to permit of economic recovery of the heat absorbed. Table III gives a summary of the heat losses in various kinds of engines (1 calorie = 3.96 b.t.u., 1 calorie per cu. m. = 0.112 b.t.u. per cu. ft.).

The *recoverable heat units* may be divided into two parts: (*a*) those in the cylinder cooling water, and (*b*) those in the exhaust gases. In small engines with automatic circulation (*a*) is dissipated by radiation from the piping leading to and from the cylinder, but in large engines, where the water is let off into the sewer, the losses are larger, because the water itself always costs something, be it only the labor of pumping it. According to Letombe, the cooling water carries off 700 to 800 calories (2772 to 3168 b.t.u.) per effective h.p-hr. While there are some engines which can do it with 35 liters (9.1 gal.), taken at 15 deg. cent. (59 deg. fahr.) and raised to 35 or 38 deg. cent. (95 to 100.4 deg. fahr.), most engines use a far larger amount of water, the temperature of which varies, of course, within closer limits, the consumption of water rising sometimes as high as 100 liters (26 gal.) per effective h.p-hr. Here an economy may be effected by providing the engine with automatic circulation and the cooling of the water down to the temperature of the surrounding air by means of surface air cooling, thus recovering the heat contained in the cylinder cooling water, and utilizing always the same water for cylinder cooling; with the water at 0.20 francs per cu.m. (say $0.0001 per cu ft.), the loss from the latter source may amount to 0.35 to 1 francs (say $0.07 to $0.19) per hour for an engine of 50 h.p. The recuperator of the heat from the exhaust gases would be placed after the air-cooler of the cooling water, and the limit of the cooling of the gases would be therefore the temperature of the air coming out of the cooler, the initial temperature of the exhaust gases varying from 450 to 600 deg. cent. (842 to 1112 deg. fahr.), in accordance with the change of load on

the engine, the average temperature being around 550 deg. cent. (1022 deg. fahr.). When properly constructed, the heat recuperator from the exhaust gases does not result in the creation of extra back pressure, since the cooling of the gas leads to the reduction of its volume, and the recuperator acts as a condenser of a steam engine.

As to the methods of recovering the heat of internal-combustion engines, the author considers mainly direct heating of air, less known than

TABLE 3 DISTRIBUTION OF HEAT LOSSES, IN CALORIES, IN INTERNAL COMBUSTION ENGINES

Kind of Engine	Per Horse-power-Hour Calories				
	Used	Lost	Losses between Producer and Engine*	Losses at Engine †	Partly Recoverable Losses
City gas engine.....	2260	1624.7	...	339	1285.7
Producer gas engine.....	2779.2	2143.9	386	416.9	1341
Large gas engine, 300 h.p. up.....	2300	1664.7	...	345	1319.7
Large producer gas engine	3000	2364.7	416	450	1498.7
Gasoline engine.....	3675	3039.7	...	551.2	2488.5
Gasoline engine.....	5250	4614.7	...	787.5	3827.2
Heavy oil Diesel engine..	1900	1264.7	...	285	979.7
Heavy oil Diesel engine..	2320	1684.7	...	348	1336.7

* The coal used is assumed to have a heating value of 7520 calories per kg. (13,536 B.t.u. per lb.), while the heat losses under this heading are assumed to be 1000 calories per kg. of coal, or 1800 B.t.u. per lb.

† These losses, as explained in the text of the abstract, are assumed to be equal to 15 per cent of the total heat used.

the system of using special boilers for heating or power purposes. This may be done in the following way: (*a*) by passing air through the engine room so as to collect the heat lost by radiation; (*b*) by passing it then through a battery of heating elements in which circulates the cylinder cooling water; (*c*) finally by passing it through a battery of heating elements through which circulate exhaust gases. The temperature of the air will thus gradually increase until the moment when it comes out of the system which it will do at the point where the exhaust gases come in, i.e., at the hottest part of the system, which is in accordance with the theoretical requirements of a good heating system. This arrangement will of course require the use of a fan, but the power consumed by the latter is insignificant as compared with the saving in heat obtained. The only part of this system which will require special design in construction will be that heated by the exhaust gases, which must have: very good joints, even though the metal will be subject to

serious expansions owing to the difference between the initial temperature of 450 to 600 deg. cent. (842 to 1112 deg. fahr.), and the final temperature which will be as low as can be obtained; it must be easy to clean, and have arrangements for removing the water of condensation formed in part by the combination of excess oxygen and hydrogen, and slightly ammoniacal; must be proof against the action of the gases and liquids contained or formed in the exhaust, mainly of basic nature, but sometimes, especially in engines using liquid fuel, also slightly acid. The author then proceeds to discuss the cases of plants having an engine of 50 h.p. driven by city gas, producer gas, and gasolene, with the recovered heat used in a dryer, and shows that, respectively, the following amounts of water may be evaporated per working day of 10 hours *practically free of charge:* 800 kg. (1763 lb.), 1268 kg. (2793 lb.), and 1035 kg. (2281 lb.).

Injurious Processes in Gas Producers (*Nachteilige Vorgänge in Gaserzeugern*, J. Hudler, *Feuerungstechnik*, vol. 1, no. 24, p. 425, September 15, 1913. 2 pp., *t*). Criticism of a statement of K. Neumann, in the latter's article, The Processes in a Gas Producer from the Standpoint of the Second Law of Thermodynamics, (cp. *The Journal*, May 1913, p. 889), that the gas leaving the fuel bed suffers a loss of 10 to 30 per cent in its heating value before it reaches the exhaust pipe. According to Neumann, this loss is due to the transformation of carbon monoxide into carbon dioxide in accordance with the formula: $2\ CO = CO_2 + C$. The gas used for open-hearth furnaces is obtained from coal, and heated in regenerators up to a temperature of 1000 to 1100 deg. cent. (1832 to 2012 deg. fahr.). The heat losses in this case are, according to Professor Simmersbach (*Stahl und Eisen*, Feb. 6, 1913, p. 239), only about 4 per cent at most, but really even less. In Neumann's test coke was used as a fuel, which practically eliminates the presence of hydrocarbons, and it was to their decomposition that the small losses in the above cited practical cases were due. Further, in practice the temperatures with which the gas leaves the fuel bed (and the gasification of coke without steam is not used practically) are considerably below those prevailing in the regenerator of the open-hearth furnace, while the time of the flow of gases through the former is also shorter than through the latter. If therefore the losses in the producer proved to be several times larger than is usual to find in the regenerator, there must be some other causes for that.

From the analysis of the data of Neumann's experiments referring to the changes occurring in the gas from its leaving the fuel bed to its reaching the exhaust, the author deduces the following facts: (*a*) increase in the contents of water, nitrogen, and, with one exception, carbon dioxide; (*b*) decrease in products of decomposition: carbon monoxide and hydrogen. The theory of decomposition of CO_2 does not explain it. On the other hand, both Neumann and Waldeck have noticed that the gas near the walls of the producer is different from that coming from the center of the fuel bed, the former (Waldeck) being sometimes entirely free from carbon monoxide. The gas in the exhaust pipe is therefore really a mixture of two gases, and that explains the increase in the content of water, nitrogen, and carbon dioxide, and the decrease in carbon monoxide and hydrogen. It

is rather surprising to find that the difference between the gases at the center and those at the edge is such as to affect to a large extent the heat relations. According to the author, this is due to the dimensions of the particular gas producer with which the tests were made which was comparatively small. The amount of gases formed in the edge section, as well as the unfavorable influence of radiation losses, depend on the dimensions of the circumference of the producer, the ratio of which to the area of a section is larger in small producer than in large ones. The author shows by calculation that while in a large gas producer the section composed of the fuel lying near the walls and easily permeable to the gases forms only 1.57 per cent of the total area; in a small producer of the size used for the tests, it forms as much as 10.4 per cent of the total area, owing to which in the latter there is a far larger production of the (low in heating value) edge gas. In addition to that, the gases in the edge section have a far greater velocity than in the center of the fuel bed, which helps further to show that the large losses in the Neumann tests were due to the small size of the producer. *Large producers work more economically than small ones.*

The fact that at full load the heat losses in the gas were smaller than at half load, is explained by Neumann by the assumption that in the former case, owing to the greater velocity of the flow of gas, there is less time left for the decomposition of the carbon dioxide. The present author explains it by the fact that, since, as was shown by Neumann in another investigation, the radiation losses are approximately constant, they form, at full load, a smaller part, in per cent, of the total heat value of the fuel than at part load, and would be double at half load, and treble at a third load. The large losses apply therefore only to small producers, while the large producers are, in the author's opinion, free from that defect, and have reached an efficiency close to the maximum possible limit.

Modern Automobile Constructions (*Neuere Automobil-Konstruktionen*, F. Klinkenberg. *Der Motorwagen*, vol. 16, no. 24, p. 597, August 31, 1913. 6 pp., 7 figs. *d*.). Description of the Windhoff touring car and its engine; the latter does not materially differ from the standard European design for low power engines.

New Gas Producer Constructions with Special Regard to Steam Boiler Firing (*Über neuere Gaserzeugerbauarten unter besonderer Berücksichtigung der Dampfkesselheizung*, Gwosdz. *Zeit. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 37 and 38, pp. 447 and 459. 7 pp., 5 figs. *de*). Discussion of new types of gas producers and their application to steam boiler firing. The *Blezinger* gas producer belongs to the carriage grate type (Fig. 3) and is primarily designed to use low-grade lignite. It works satisfactorily with the German lignites which have a high water content (40 to 65 per cent) and a tendency to large formation of clinker. Its chief advantage lies in the ease with which ash can be removed. The shaft *b* jacketed in its lower part, and reaching down nearly to the grate carriage *a*, is supported on four columns. The upper part of the shaft is brick-lined; the lower part is formed by a cast-iron water-cooled ring *c*, the purpose of which is to prevent the

baking of clinkers on the shaft walls. In the latest types this cooling mantel is designed as a boiler furnishing steam required for the working of the gas producer (this type is shown in Fig. 3). The producer itself is covered by a plate supplied with a peculiar lifting apparatus consisting of a truncated cone *d* provided with two openings *e* and *f* over which are placed two conveyor rolls *g* and *h* uninterruptedly bring-

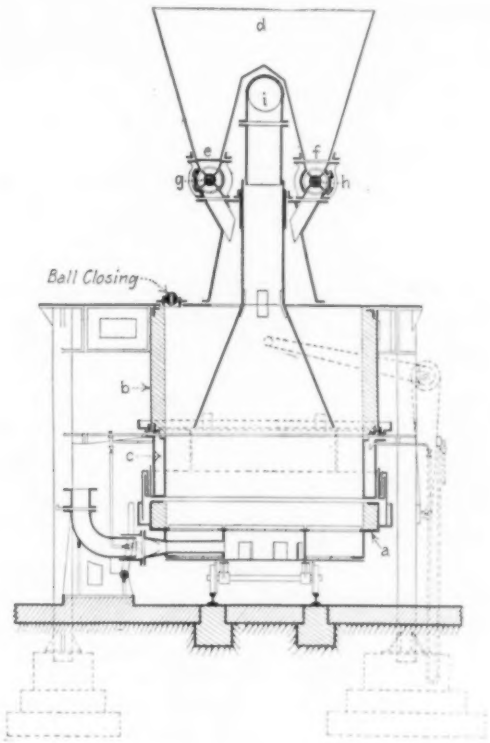

FIG. 3 BLEZINGER GAS PRODUCER

ing in coal at a uniform rate from the bunkers above. From the upper part of the truncated cone hangs the gas escape pipe *i*, for the escape of gases from the inside of the coal bed, the thickness of the bed being regulated in such a manner that the lower end of the pipe is always in the coal. Between the edge of the shaft and the face of the grate carriage there is a space of 50 mm (say 2 in.) permitting always free motion of the grate carriage; during the running of the producer, this space is packed off by means of a movable sheet of iron dipping into a water seal. Should there be a formation of clinker, a previously cleaned grate carriage is connected with that under the producer, the new carriage having its grate basket filled to the top with fuel in large chunks. When this carriage is shoved in, the clinker layer of the

producer is cut off, without effecting any change in the fuel column. This change of grate carriages takes from 5 to 7 minutes. When fuel with high water content is treated, the gas is led through a water-cooled washer where most of its moisture is removed.

The above described arrangement is goood only if the amount of fine coal in the fuel is not too large. When fuel containing, say, more than 60 per cent fine material, is thrown cold into the producer shaft, the water and tar vapors, in passing through the cold fuel bed thus formed, condense, and in a short time a dough-like mass is formed which does not permit the gas to pass through, so that the action of the producer stops. A special type has therefore been designed (described and illustrated in the original) with a delivery drum in which the fuel is heated up to 75 deg. cent. (167 deg. fahr.) previous to being thrown on the fuel bed. Complete data of tests of double-flue boilers, without either superheaters or economizers, fired by gas from Blezinger gas produce are cited.

An Important Discovery (*Eine wertvolle Entdeckung*, Mk. *Allgemeine Automobil-Zeitung*, vol. 14, no. 38, p. 15, September 20, 1913. 1 p. *g*). The author compares the statement of the Petrol Substitutes Committee of the Royal Automobile Club of Great Britain with that of Mr. Armitage, president of the British Motor Spirit Syndicate, and expresses the belief that the process of the latter is similar to that announced by the Petrol Substitutes Committee, his process consisting in passing a mixture of oil and steam, at a certain temperature, through pipes containing nickel rods. The nickel acts in such a manner that the hydrogen of the steam unites with the oil, and transforms it into a lighter oil making a good motor fuel (Lamplough process).

Measuring Instruments

Concerning the Problem of Controlling the Output of Blowers (*Zur Frage der Leistungskontrolle der Gebläsemachinen*, G. Jakob-Marzella. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 25, p. 392, September 10, 1913. 1 p., 2 figs. *d*). With the modern high speeds of blast (up to 75 m per sec. or 246 ft. per sec.) the usual measuring and registering apparatus cease to give satisfaction. Micromanometers and apparatus of the pitot tube type are unsatisfactory for an extended period of operation and with rapidly varying velocity of blast, the pitot tube being in addition unfavorably affected by eddies in the air passages which cannot be fully eliminated with a strong blast. All these disadvantages are said to have been eliminated in the *anemotachometer* of Wilhelm Morell in Leipzig (Fig. 4), which is like an ordinary anemometer with the difference that the integrating device of the latter is replaced here by a centrifugal pendulum with an indicator pointer. It was feared at first that the inertia of the pendulum and other parts and the friction in the bearings would unfavorably affect the sensitiveness of the indications (tests have shown that with a small blast it takes several seconds for the anemotachometer to pass from its state of rest into full motion), but this inertia lag becomes smaller as the wind increases, and for blasts within the limits of technical application becomes quite negligible; it was proved further by tests that the anemotachometer follows the changes in the blast as closely as a micromanometer with a pilot tube.

The instrument is very easy to read. An anemotachagraph was built and gives satisfaction for the measurement and recording of the velocity of a dirigible airship. The anemotachograph is described and illustrated in the original article.

CH. FÉRY THERMO-ELECTRIC CALORIMETRIC DIRECT READING BOMB (*Bombe calorimétrique thermo-électrique à lecture directe, système Ch. Féry, Le Génie Civil*, vol. 63, no. 21, p. 415, September 20, 1913. 1½ pp., 1 fig. *de*). Description of a new calorimetric bomb. Its distinctive features are: no water is used as the calorimetric mass, the metal of the bomb taking its place, and, second, the rise of temperature produced by the combus-

FIG. 4 MORELL ANEMOTACHOMETER

tion of the sample is evaluated by a thermo-electric process. The apparatus is shown in Fig. 5, and consists of the calorimetric bomb proper maintained in the center of a metallic envelop *A* by a disc *E*. The combustible under test is placed in the capsule *J*, and ignited by an electric current sent through a fine wire running between the rods *K* from a small magneto used for that special purpose. *D* is the outside coating; previous tests having shown that thin steel does not insure perfect conductivity of heat, and that this fact leads to lack of uniformity in results, red copper is now used for the coating, 3 to 4 mm (0.118 to 0.157 in.) thick. *C* is the inside nickel coating which can be easily removed in order to weigh the moisture formed. The capsule *J* is always placed at the same height by means of an adjustment shown on the rod supporting it. The current to the wire located between the rods *K* is brought in from the outside contact screws *G*. Oxygen is admitted through

the cock *F*, and is thrown out in four horizontal jets, so as to avoid the blowing away of combustible if the latter happens to be in the state of powder. The heat produced is read from the millivoltmeter *L* either in millivolts, or directly in calories, the latter being possible, of course, only when the amount of combustible is equal to the unit weight for the system of heat units used. Tests made with instruments at the Laboratory of Arts and Trades in Paris (the original article contains some data of these tests) have shown the reliability of the instrument.

CONCERNING A NEW METHOD FOR MAKING VISIBLE STREAM LINES IN LIQUIDS (*Über ein neues Verfahren, die Stromlinien in Flüssigkeiten*

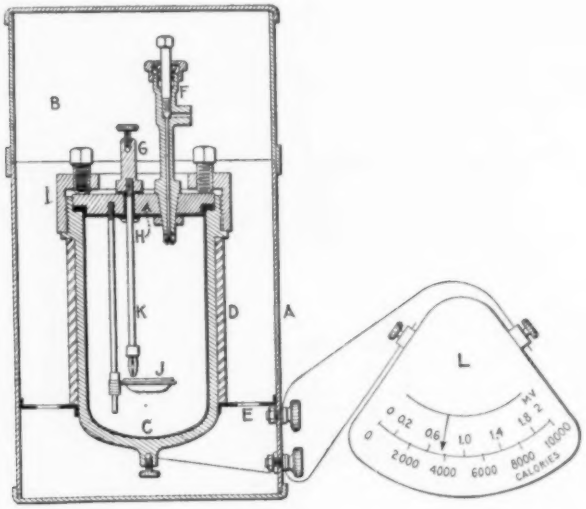

FIG. 5 FERY THERMO-ELECTRIC DIRECT READING CALORIMETRIC BOMB

Sichtbar zu machen, R. Katzmayr. *Mitteilungen des K.K. technischen Versuchamtes* (Vienna), vol. 2, no. 3, p. 46, 1913. 5 pp., 3 figs. *d*). Discussion of methods for making visible stream lines in solids, liquids and gases. The author recommends the following new method for making visible stream lines in gases. He proposes to hang up a large number of short and very light threads arranged so as to follow one another, without being in mutual organic connection. To eliminate as far as possible the influence of the force of gravity, the flow of the gas may be made vertically downwards. The threads then follow the stream line in the gas flow, which they can do with great precision through being light and short, while the arrangement of a large number of consecutive threads permits the stream lines to be visible even in an eddying flow. The method is exact only for flows having velocities different from zero, and depends on the weight, or rather lightness, of the threads used. Tests have shown that the presence or absence of other threads in front or behind a thread does not affect its indications; there is therefore no screening effect on

one thread due to the presence of another. The method of attaching the threads does not materially affect the correctness of their indications.

Pumps

CONCERNING THE VARYING INFLUENCE OF THE MOST SUITABLE ANGLE OF COUPLING AND RATIO OF (PISTON) CROSS-SECTIONS ON THE DIMENSIONS OF THE FLYWHEEL IN COUPLED DOUBLE-ACTING TWIN PUMPS (*Über den wechselnden Einfluss des günstigsten Kupplungswinkels und Querschnittsverhältnisses auf die Schwungradabmessungen bei gekuppelten doppelwirkenden Zwillingspumpen*, Karl Mayer. *Zeits. des Oesterr. Ingenieur- und Architekten-Vereines*, vol. 65, no. 38, p. 630, September 19, 1913. 2 pp., 4 figs. *t*). This article is virtually a continuation of the author's articles in *Die Fördertechnik* (see abstract in *The Journal*, October and November 1912, pp. 1574 and 1891). Only the conclusions to which the author arrives are here reported. The keying on the cranks of coupled double-acting twin pumps to the most suitable angle with respect to the maximum velocity of the suction or pressure water column affects favorably the hydraulic efficiency of the pumps, but has a contrary effect on the dimensions of the flywheel. With the crank drive ratio $\lambda = 1/5$ and the application of the method equality of alternately opposite piston areas (see more below) the weight of the flywheel may be made by 0.4 lighter than when the working cross-sections of the pistons are equal, and the cranks are keyed at an angle of coupling of 90 deg. If $\lambda = 1/3$, the weight of the flywheel is only 0.4 of what it would have been with equal working cross-sections of the pistons and coupling of the pumps under an angle of 90 deg. The method of making the area of the upper side of one of the pistons equal to that of the lower side of another and vice versa, with due regard to the most suitable ratio of cross-sections to the maximum velocity of the suction or pressure water column, affects favorably the dimensions of the flywheel, and the more so, the shorter the connecting rod. When the combined process is used, i.e. when, in addition to the equality of alternately opposite piston areas, the angle of coupling is different from 90 deg., the flywheel dimensions are not as attractive as when the method of equality of alternately opposite piston areas is *alone* used, and, when the equality of maximum velocity in all the four phases (see *The Journal*, October 1912, p. 1574) is preserved, only 0.2 of the flywheel weight is saved. The author therefore arrives at the following general conclusion: with the most suitable angle of coupling, a high hydraulic efficiency of the pumps is attained only at the cost of larger dimensions of the flywheel. When the area of the upper side of one of the pistons is made equal to that of the lower side of another, and vice versa, a saving in the weight of the flywheel is obtained simultaneously with a comparatively high hydraulic efficiency. A further improvement of the hydraulic efficiency by preserving the equality of alternately opposite areas of the pistons, and making the angle of coupling differ from 90 deg., leads to a material decrease in the saving in the weight of the flywheel.

THEORETICAL AND GRAPHICAL STUDY OF CENTRIFUGAL PUMPS (*Étude théorique et graphique des pompes centrifuges*, J. Dejust. *Revue de mécanique*, vol. 33, no. 3,

p. 209, September 30, 1913. 48 pp., 32 figs. *mtA*). By means of a combination of graphical and mathematical methods the author arrives at a process for determining the forms of blades, wheel, collectors and diffusors of centrifugal water pumps, as well as predetermining their characteristic curves. The exposition of this process is preceded by an interesting discussion of the theory of water turbines, omitted here owing to lack of space.

The centrifugal pump supplies the energy to a mass of water so as to lift it to an upper level. If two sections, M and M' (Fig. 6A) be considered, between which energy is supplied to the water, the following equation is obtained

$$\frac{V'^2}{2g}+\frac{p'}{\omega}+z'=\frac{V^2}{2g}+\frac{p}{\omega}+z+T+\eta_i \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where V and V', p and p' are the velocities and pressures in the sections M and M' respectively, z and z' the altitudes of the centers of gravity of the two sections, T the total energy supplied to 1 kg. of water between these two sections, which must be sufficient not only to lift the water to the height H but to overcome all the losses of head due to resistances in the piping and pump. With the following notation T may be expressed as in equation [2]: η_a loss of head in the suction piping and passages at the entrance to the pump; η_i loss of head in the movable part of the pump; η_e losses in the diffusors of collectors of the pump, and the discharge piping.

$$T=H+\eta_a+\eta_i+\eta_e=H_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

The term η_e includes the losses due to the fact that there is an unused head through the water being discharged at a higher head than is absolutely necessary for its operation, as well as through the non-use of the kinetic energy of the water flowing out of the pump. The head H_1 is therefore called *fictitious head*. By substituting in equation [1] for T its value from equation [2] the *general equation of water pumps* is obtained:

$$\frac{V'^2-V^2}{2g}+\frac{p'-p}{\omega}+\eta_i=H_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [1']$$

which shows, that when the water leaves the pump, energy is stored in it in two forms; one, kinetic, represented by the member $\frac{V'^2-V^2}{2g}$, and the other, potential, by the member $\frac{p'-p}{\omega}$. The velocity of discharge V' decreases therefore when the potential energy increases. In practical applications, however, there is reason for having the water in the conduits flow at a relatively low speed (1 to 2 m., or say, 3.2 to 6.5 ft. per sec.), while at the discharge the velocity rises as high as 40 to 50 m. (131 to 164 ft.). If the speed were suddenly reduced from 40 or 50 to 1 or 2 m., by means of some loss in head, all the corresponding energy would have been lost, which does not happen when the reduction in speed is effected by a gradual increase in section, i. e., by a conversion, or *diffusion* of velocity into pressure. Since the potential energy of the water is only a fraction of the total energy H_1, it can be expressed as a function of the latter

$$\frac{p'-p}{\omega}+\eta_i=\epsilon H_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [4]$$

where the symbol ϵ is analogous to that expressing the degree of reaction in a turbine, with the difference, however, that it expresses here the *degree of diffusion*, or the opposite phenomenon. It is by the use of this new element of calculation

that the author claims to have succeeded in building up a theory of pumps fully similar to that of turbines.

By substituting ϵH_1 for its equivalent in equation [1'], the following is obtained:

$$\frac{V'^2-V^2}{2g}=H_1(1-\epsilon) \quad \text{.....[II]}$$

This equation shows among other things that when the diffusion is fully taken care of in the movable wheel, the speed at discharge is the same as that at entrance to the pump.

By applying the Bernouilli theorem to the relative motion of the water in the wheel, the following equation is obtained

$$\frac{w'^2-u'^2}{2g}+\frac{p'}{\omega}+z'=\frac{w^2-u^2}{2g}+\frac{p}{\omega}+z+\eta_i \quad \text{.....[5]}$$

where w and w' are the relative velocities, while u and u' the speeds of rotation at the entrance to, and discharge from, the wheel respectively. From this equation is obtained

$$\frac{p'-p}{\omega}+\eta_i=\frac{u'^2-u^2}{2g}-\frac{w'^2-w^2}{2g}=\epsilon H_1 \quad \text{.....[6]}$$

which, when substituted into the general equation (1') gives it the form

$$\frac{V'^2-V^2}{2g}+\frac{u'^2-u^2}{2g}-\frac{w'^2-w^2}{2g}=H_1 \quad \text{.....[I } \textit{bis}\text{]}$$

analogous to the equation of velocities for turbines. Further, by making use of the triangle of velocities at the discharge from, and entrance to the pump, the author derives the equation

$$\frac{2V'u'\cos\alpha'-2Vu\cos\alpha}{2g}=H_1 \quad \text{.....[I } \textit{ter}\text{]}$$

where α and α' are the angles between the absolute velocities and the velocities of entrainment.

Calculation of a centrifugal pump. For a given range of operation in which the values H_1, V, and η_i are known, there is a system of three equations: [I *bis*] or [I *ter*], [II], and five unknowns: V', u', u, w', w, if equation [I *bis*] is used, and V', u', u, α', α, if equation [I *ter*] is used. Two conditions must therefore be either assumed or determined in some other manner, since otherwise there will be several solutions for each problem, with a definite hydraulic efficiency corresponding to each solution. The hydraulic efficiency of a pump is determined from the following formula:

$$\rho=\frac{gH}{gH_1}=\frac{H}{H+\eta_a+\eta_i+\eta_e}=\frac{1}{1+\frac{\eta_a}{H}+\frac{\eta_i}{H}+\frac{\eta_e}{H}} \quad \text{.....[7]}$$

For a definite installation and range of operation $\frac{\eta_a}{H}$ and $\frac{\eta_e}{H}$ are constant whatever pump be used, but $\frac{\eta_i}{H}$ depends on the relative velocity of the water in the pump, section of the wheel and moistened perimeter corresponding to that section: $\eta_i=\frac{X}{\Omega}B_1w^2$, and, since a given output gives for $\frac{X}{\Omega}B_1$ values practically equal for all types of pumps, it may be safely assumed that the loss η_i is proportional to the square of the relative velocity, and, therefore, to attain the maximum

hydraulic efficiency, it is only necessary to select the supplementary conditions and data in such a manner as to have the relative velocity a minimum. These data are: H_1, V, and η_i. Neither H_1 nor V, although the first is indirectly in functional relation with w, materially affect the latter. On the other hand, as shown by equation [6], in order that ϵ give the minimum relative velocity, the supplementary conditions must be selected in a certain manner, since the value of u, and through it those of u', w and w' also depend on these conditions. The minimum of η_i depends, as shown above, on the relative velocity being minimum, but the relative velocity is variable at the entrance and discharge, and, for given degrees of diffusion and velocity of rotation, the relative velocity of entrance varies in the same sense as that of discharge. It is therefore enough to make the relative velocity of discharge minimum.

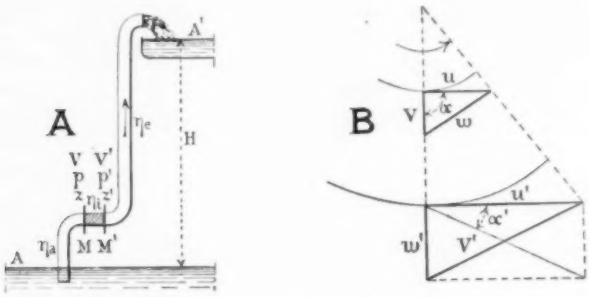

FIG. 6 CENTRIFUGAL WATER PUMPS DIAGRAMS

The author proves further that the minimum of w'^2 corresponds to the *maximum* of the degree of diffusion, a fact which is proved also by tests of pumps designed by other methods. He also proves that the minimum value of w' is determined by the conditions that $V'=u'$, and angle α' be as small as possible, the upper limit of the degree of diffusion being given by the equation

$$\epsilon<\frac{1}{2}+\frac{V^2}{2gH_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots[8]$$

This process is applied by the author to the calculation of several types of water pumps. As an example the part referring to the old type Farcot pump is here reported. This pump is characterized by radial entrance and discharge (Fig. 6B), i. e., the absolute velocities of entrance and discharge are both directed radially, which fact gives the two supplementary conditions: $\alpha=90$ deg., and $V'^2=u'^2+w'^2$, or $u'=V'\cos\alpha'$. The general equation for angles [I *ter*] becomes therefore: $u'^2=gH_1$, which indicates the tangential velocity to be given to the wheel in order to obtain the head H_1. With u, V and α known, the triangle of velocities at the entrance is determined; to find that at discharge it is necessary to know V' and α'. V' is given by the general equation [II] when the degree of diffusion ϵ is given:

$$\frac{V'^2}{2g}=\frac{V^2}{2g}+H_1(1-\epsilon) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots[9]$$

while α' is given by the second initial condition, from which $\cos\alpha=\frac{u'}{V'}$. To make

the solution possible, it is further necessary that $\frac{u'}{V'}<1$ or that $u'^2<V'^2$. That is to say

$$gH_1<V^2+2gH_1(1-\epsilon)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots[10]$$

and hence

$$\epsilon<\frac{1}{2}+\frac{V^2}{2gH_1}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots[11]$$

which shows that in pumps of this kind the degree of diffusion must be between zero and $\left(\frac{1}{2}+\frac{V^2}{2gH_1}\right)$. To find their efficiency w'^2 must be expressed as a function of the degree of diffusion ϵ which can be done from the expression $w'^2=V'^2-u'^2$, or as

$$w'^2=V^2+gH_1-2gH_1\epsilon$$

which also shows that the minimum of w'^2 corresponds to the maximum of the degree of diffusion.

In the second part of the article which will be reported in a future issue of The Journal, the author shows how to determine graphically the various elements in the design of centrifugal pumps; among other things, the characteristic curves of the pumps designed.

Steam Engineering

WATER PURIFICATION BY MEANS OF PERMUTIT AND ALLAGIT (*Die Wasserreinigung mit "Permutit" und "Allagit"*, W. Beck. *Zeits. für Dampfkessel und Maschinenbetreb*, vol. 36, no. 38, p. 463, September 19, 1913. 2 pp., *g*). The most interesting part of the article is that referring to *Allagit*, a substance discovered by Kobelt, in Germany. Allagit is a purified volcanic lava, possessing like the natural zeoliths, the property of easily exchanging bases with the salts contained in water. Allagit is neither a chemical compound nor a zeolith, and its constituent parts are not always present in their stoichiometric ratios. It is applied in the same manner as permutit, and is equally regenerated by a 4 to 5 per cent cooking salt solution.

NATURAL OR MECHANICAL DRAFT IN STEAM PLANTS (*Natürlicher oder künstlicher Zug bei Dampfanlagen*, Fr. Barth. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 37, p. 1455, September 13, 1913. 8 pp., 8 figs. *cd*). With all its well-known advantages, mechanical draft is more economical than natural draft only under certain conditions: where short working periods or high peak loads of short duration are required, or where it is possible, by forcing the boiler by means of mechanical draft to reduce either the first cost of the plant, or the consumption of coal for starting the boiler or keeping the auxiliary boilers under steam. Mechanical draft in itself does not improve the conditions of firing or efficiency of the boiler plant, and acts favorably on the combustion and output of smoke and soot only where the smokestack is too small. Under certain conditions, however, the trouble may also be removed by a reconstruction of the furnace (increasing the free grate areas), or of the boiler flues (lowering the gas velocity, and providing plenty of room at the points where the gas stream changes its direction), or by raising the stack. It may therefore be expected that in the future as well as at present

natural draft will be the rule, and mechanical draft an exception. With the exception of movable plants (locomotives, locomobiles, ships) mechanical draft is to be used where the conditions of operation are such that the load on the engines cannot be determined in advance, or where the stack draft has become insufficient through the expansion of the boiler plant or introduction of flue gas preheaters, blast heaters, dust collectors, etc. It may also be used to advantage where there are large fluctuations of load, or where cheap coal is burned, offering a large resistance on the grate. It will also be used, of course, where for aesthetic or other reasons a smokestack cannot be built. For steam plants working in

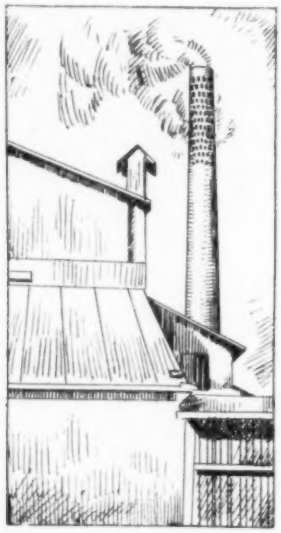

FIG. 7 DISSIPATOR SMOKESTACK

connection with, and as an auxiliary to, water power plants, mechanical draft is to be preferred to natural, on account of its being ever ready to work. The smokestack and blower do not therefore completely exclude one another. In most cases of stationary plants, however, the blower is not so much a substitute for, as an auxiliary to, the stack.

GRID SMOKESTACK (DISSIPATOR SMOKESTACK) AND ITS INFLUENCE ON THE SMOKE NUISANCE (*Gitterschornsteine Dissipatorschornsteine*) *und ihr Einfluss auf Rauchschäden*, H. Winkelmann. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 37, p. 449, September 12, 1913. 2 pp., 2 figs. *d*). The attempt to obviate the smoke nuisance by the use of exceptionally high smokestacks failed, mainly because the upper layers of the atmosphere proved to be less subject to eddies than the lower strata, and therefore did not produce as rapid a mixing of the smokestack gases with the atmosphere as when a low smokestack was used. An attempt was therefore made to produce the eddy action artificially, and the apparatus described below is the result. It was designed by Professor Wislicenus who has for a number of years been investigating the smoke problem.

The *dissipator* is the upper grid-like section of an otherwise ordinary commercial type smokestack, and has for its purpose to mix the gases coming out from the stack so intimately with the air as to make them harmless. The grid openings (Fig. 7) are formed by stones laid radially and provided with horizontal and conic holes, with a total cross-section five to six times that of the usual upper opening (the cross-section of these grid passages is a function of the upper inner diameter of the stack). The wind enters on one side of the stack through these conical openings, mixes under powerful eddy motion with the smoke and gases in the stack, and produces, already in the stack, a dilution of the latter to nearly one in four; after this the mass of smoke and gases strongly diluted with air is driven out, also violently eddying, through the conical openings on the other side of the stack all along the dissipator. Thus, while from an ordinary stack the smoke and gases come out in a compact mass from a single opening, in the dissipator smokestack they come out in a number of fine wreaths, strongly diluted with air. They rapidly become still more closely mixed with it, to nearly one part in ten, the dilution of the gases growing with the distance from the stack.

When the dissipator smokestack is used, only a haze, but no smoke crown, can be noticed around the top of the stack. With respect to draft, the solid closed portion of the stack must be high enough to take care of that, while the grid section may contribute to its improvement. The cost of the dissipator stack is somewhat greater than that of an ordinary stack on account of the price of the special brick used for the grid section. In the design the main question is to have the grid pass gradually from a few holes to a complete grid on top.

Miscellanea

Pipe Foundry Ardelt (*La fonderie de tuyaux Ardelt. Revue industrielle*, vol. 44, no. 2102/37, p. 505, September 13, 1913. 4 pp., 12 figs. *d*). Detailed description of the foundries for manufacturing cast-iron pipe, one belonging to the Anderten Company in Germany, and another to the General Conduit Company, in Liège, Belgium.

Boiler Inspection Associations In Russia (*Die Dampfkessel-Überwachungsvereine in Russland*, G. von Doepp. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 35, p. 1389, August 30, 1913, 2 pp., 3 tables, *dhs*). Gives a history of the organization of boiler inspection associations in Russia. The associations are to a large extent under government control, the engineers of the associations having the privileges of government service, and the members receiving a 50 per cent rebate in the boiler tax (the tax is on a sliding scale, 4.4 cents per sq. ft. of heating surface up to 200 sq. ft., 3 cents per sq. ft. from 200 to 1000, and 1.5 cents per sq. ft. for all upward of 1000 sq. ft.; owing to the spread of internal-combustion engines it is proposed, however, to modify the tax in such a way as to include the latter also).

The article gives some statistical data as to the boilers used in the country. By age, 34.76 per cent of the boilers belong to the period 1891-1900, and 35.36 per cent have beeen installed after 1900; over 10 per cent are older than 1890, some boilers being older than 1870. The distri-

bution, in per cent, by fuel used is as follows: 3.1 anthracite, 12 wood and wood refuse, 13.8 oil residues, 2 peat, 3.5 gas, 2 mixture of fuel. Of the total of 17,287 boilers registered in the country, there were 1259 battery and single-cylinder boilers, 6992 flue boilers, 1342 multitubular boilers, 1892 locomotive boilers, 2908 water-tube boilers, etc. No data are given as to the number of boilers made in the country and imported, but the number of the latter can hardly be large.

NECROLOGY

EDWIN S. CRAMP

Edwin S. Cramp, until recently vice-president and general manager of the William Cramp & Sons Shipbuilding Company of Philadelphia, Pa., was born in Philadelphia, March 1853. He was the son of Charles H. Cramp and the grandson of William Cramp, founder of the great shipyard that has been known as "the cradle of the navy." He obtained his education in the Philadelphia public schools, graduating from the Central High School in 1871. In the fall of that same year he was apprenticed to the engineering department of the Cramp company and served his four years there, becoming an expert machinist. He then left the machine shop for the drafting department where he spent seven years, familiarizing himself with all details of naval designs. Following this he was placed in charge of the erecting department, erecting all marine engines used by the company, and was subsequently made superintendent of the plant. From this position he rose to general manager of the entire shipyard and in October 1901, on the death of Henry W. Cramp, he became vice-president of the company.

He retired from business a few years ago and moved to New York, where death came on June 20, 1913, as the result of a surgical operation which he underwent about a year ago, leaving him in shattered health. He survived his father by only two weeks. His work side by side with his father for 35 years was effective in making the Cramp company foremost in the production of our "new navy;" his technical and practical training was the cause of exceeding specifications in many trial trips of completed vessels which were run by himself personally and netted the company large sums as bonuses. Mr. Cramp was vice-president of the Society from 1896 to 1898 and was identified with the Pennsylvania Society, American Academy of Social Science, the Geographical Society, Naval Architects and Marine Engineers, and the Engineers Club of Philadelphia.

FRANCIS VALENTINE TOLDERVY LEE

Francis V. T. Lee was born at Winchester, Hampshire, England, August 28, 1870, and attended the grammar school at Manchester, England, and the College Communal at Boulogne, s.m., France. He came to Sherbrooke, Canada, in 1887, and for the greater part of three years was in the service of the Canadian Pacific Railway as secretary to the chief of construction, in charge of the forwarding of material. After resigning from railroad work he spent a year in England and then returned to New York where he remained a year in the employ of the Manhattan Electric Light Company, as assistant under E. E. Stark. Here he came into contact with the late F. A. C. Perrine and formed the acquaintance that so strongly influenced his career.

He left New York to take up the study of electrical engineering at Leland Stanford Junior University, in California, under Dr. Perrine, who was then professor of electrical engineering there. He worked his way by helping Dr. Perrine as secretary and general laboratory assistant. Shortly after being graduated from the university in 1897, he was appointed assistant engineer to John Martin, agent for the Pacific Coast department of the Stanley Electric Manufacturing Company. He rose rapidly in this service, being appointed engineer in January 1898, manager of the office in June 1899 and a year later was made vice-president and general manager of John Martin & Company, electrical engineers and contractors, also district Pacific Coast manager for the Stanley Electric Manufacturing Company, and many other Eastern manufacturers. During this period there came under his direct supervision the erection of many of the earlier lighting and power plants that later were absorbed by the Bay Counties Power Company and the Pacific Electric Railway Company. Early in 1906 he severed his connection with John Martin & Company, but followed Mr. Martin's interests into the Pacific Gas & Electric Company, where he was made assistant to the president; as such he was generally responsible for the construction and operation of the hydro-electric developments of that company. About three years ago he resigned from the service of the Pacific Gas & Electric Company to rest, and his last three years were spent at his old home in England and in traveling on the Continent. He returned a few months ago to Victoria, B.C., where he had intended to make his future residence and died there August 17, 1913. He was a member of the American

Institute of Electrical Engineers, of the American Society of Civil Engineers, of the American Gas Institute, of the American Electrochemical Society, and of the Institution of Electrical Engineers in England.

SAMUEL EDWARD MITCHELL

Samuel Edward Mitchell was a native of England, having been born at Halifax, in June 1875, and received his education at the Halifax Higher Grade School and at the Halifax Technical School. In 1892 he was apprenticed with Fred Hanson & Company, machine tool builders of Halifax, in the works on machines, and two years later went to the Campbell Gas Engine Company, also of Halifax, gas and oil engine builders. He remained two years in the works here and then was promoted to the drafting room, where he remained until 1902, having risen to assistant chief draftsman when he left. In August 1902 he became chief gas engine designer for Tangyes, Ltd., in Birmingham, England, and remained there until April 1905, when he became head of the gas engine department of Ruston, Proctor & Company of Lincoln, England. After two years spent with this company, he came to America and became identified with the Jacobson Engine Company of Chester, Pa., where he remained two years as superintendent, building engines up to 400 h.p. In 1909 he spent nearly a year as gas engine designer with the Minneapolis Steel & Machinery Company, of Minneapolis, Minn., on their large double-acting gas engines. From July 1910 until his death he was general superintendent of the Geo. D. Pohl Manufacturing Company, of Vernon, N. Y., builders of gas and gasolene engines; he had just completed designs of a new line of gas engines for this company and was engaged in some important developments in oil engines at the time of his death, August 19, 1913.

THURSTON MASON PHETTEPLACE

Thurston Mason Phetteplace was born at Providence, R. I., on May 3, 1877, and received his education there, in the English and Classical High Schools, and in Brown University, where he was graduated in 1901 in mechanical engineering. After leaving school he was employed at the Builders Iron Foundry and as instructor in drawing at Brown University, later becoming instructor in mechanical engineering there. In 1909, he received

a degree of Master of Arts from Columbia University, and was appointed associate professor of mechanical engineering at Brown University. At the time of his death on September 7, 1913, he was engaged, in addition to his professorship, in consulting work in the firm of Kenerson, Brooks & Phetteplace, his specialty being automobile construction and gas engine design. He was president of the Providence Association of Mechanical Engineers, and held membership in the Society for Promotion of Engineering Education.

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DIE ENTSTEHUNG DES DIESELMOTORS, Rudolf Diesel. *Berlin, J. Springer, 1913.* Gift of author.

A presentation copy "To The American Society of Mechanical Engineers, in remembrance of the kind reception given me in New York in 1912, and of your trip to Germany and especially to Munich in 1913." It gives the results of tests of the engine which the author invented. It is especially interesting to note the experiments with coal dust fuel.

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Mr. Moseley was for 20 years secretary of the Interstate Commerce Commission, and was a pioneer in advocating the introduction of safety appliances on railroads.

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DINNER GIVEN TO CASS GILBERT, ARCHITECT, April 24, 1913, F. W. Woolworth. *New York, 1913.* Gift of author.

DUTIES OF THE BUREAU YARDS AND DOCKS (reprint from Confidential Bulletin no. 13, Public Works of the Navy), June 1913. *Washington, 1913.* Gift of Alfred Noble.

FIRE TESTS OF FLOORS IN THE UNITED STATES, I. H. Woolson. (International Association for Testing Materials, 6th Congress, New York). *New York, 1912.* Gift of author.

OM HÄSTSKOSÖMMET OCH DESS TILLVERKNING SAMT NAGRA DRAG UR HOFBESLAGETS HISTORIA, K. J. Sunström. *1911.* Gift of F. B. Gilbreth.

The author desires very much to have samples of every kind of horseshoe nail that there is, in order that his next book on this subject may include American as well as European. K. J. Sunström, Orebro, Sweden.

INTERNATIONALEN KÄLTEKONGRESS (DRITTEN) FESTSCHRIFT, Washington–Chicago, September 15-24, 1913. *Berlin, 1913.* Gift of congress.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION. Forms for special assessments, Illinois. *1913.*

———Work Scenes. Vitrified Brick Roadway. Gift of association.

OHIO. PUBLIC SERVICE COMMISSION. Report, 1912. *Springfield, 1913.*

———A compilation of the laws of Ohio affecting the Regulation of Railroads and Public Utilities, 1913. *Columbus, 1913.*

———An act to create the public utilities commission of Ohio to prescribe its organization, etc. *1913.* Gift of commission.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION. Proc. 20th annual meeting. Vol. 20, pt. 2. *Ithaca, N. Y., H. H. Norris, 1913.* Gift of society.

An especially interesting series of papers on engineering laboratories. Professor Magruder of Ohio State University made a visit to about twenty-five American mechanical laboratories, and summarizes his discoveries.

THIRTY YEARS OF NEW YORK, 1882–1912, being a history of electrical development in Manhattan and the Bronx. *New York, Press of New York Edison Company, 1913.* Gift of New York Edison Company.

This is an extremely interesting volume, giving not only a history of the company, showing its marvellous growth, but containing much matter relating to old-time New York, the New York of the horse car, the gas-light, and the elevatorless building; a city without electric cars or telephone. The work is profusely illustrated, having many reproductions of sketches by Joseph Pennell, Vernon Howe Bailey and others.

EXCHANGES

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS. Trans. vol. 7. *New York, 1911.*

BROOKLYN ENGINEERS CLUB. Proc. 1912. *Brooklyn, 1912.*

ECOLE D'APPLICATION DU GENIE MARITIME. Cours de Construction du Navire. Vol. 3. 1910–1912.

TRADE CATALOGUES

ASBESTOS PROTECTED METAL CO., *Beaver Falls, N. Y.* Bull. 53, asbestos for roofs and walls.

BESELER, CHAS. CO., *New York.* The stereomotorgraph model C.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity magazine, August 1913.

WAGNER ELECTRIC MANUFACTURING CO., *St. Louis, Mo.* Bull. no. 101, single-phase motors, September 1913; no. 102, poly-phase motors, October 1913.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

925 General manufacturing man thoroughly experienced in gas engine work and the handling of men. An excellent opportunity. State age, compensation desired, full experience and reference. Apply through the Society.

926 Machine and tool expert, thoroughly experienced and capable of taking charge of planning and rate setting department in a large gas engine shop; must have good habits and self control. State age, compensation, full experience and references. Apply through the Society.

928 Competent man with mechanical designing ability, to act as chief engineer and general superintendent of plant manufacturing large and heavy machinery. Location, Michigan.

930 Railroad engineer, experienced in selling goods, acquainted with railroad officials, preferably not over 35 years of age.

1001 Works engineer, preferably man with technical education, familiar with overhead cranes, open-hearth furnaces, tracks and all machinery and buildings required in a steel foundry, to have charge of plant engineering department and construction work outside of that handled by the master mechanic. Excellent opportunities for a man who can satisfactorily fill this position. Salary not to exceed $175 per month. Location, Illinois. Apply through the Society.

1003 Mechanical engineer with experience in production engineering, or in the Taylor system of scientific management, or one having a liking for this kind of work; Cleveland concern.

1004 Two vacancies in section of wood preservation Forest Products Laboratory. Men wanted with ideas and originality; large experience is not essential; must be graduates of technical institutions. Examination will probably be held within the next three to six months and will have to be passed by those securing the positions. Howard F. Wein, United States Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wis.

1005 Thoroughly practical, hustling shop foreman, experienced in engine and pump work; a thorough mechanic, able to produce the maximum output of highest quality at lowest cost, and familiar with best and latest

up-to-date practice. State age, experience, references, and compensation expected. Apply through the Society. Location, Massachusetts.

1006 Assistant shop manager, good judge of workmen, accustomed to careful and accurate manufacturing; $1500 a year. Location, Pennsylvania.

1007 Man educated in one of the first-class technical schools, preferably with degree of mechanical engineering and who has done practical work with marked success in machine designing; good administrator, of large vision and proven ability whose record is convincing beyond any question; man who commands respect with people in a business way and who can win the enthusiasm of those working under him; technical knowledge as an engineer should be both deep and broad in all things having to do with the origin and development of machinery. Apply through the Society in written application to No. 1007.

1008 Efficiency engineer, for a time under instruction, in plant of 700 workers. Position permanent and good opening for a bright young man of three or four years experience in practical work and with the desire and the training that will make success in this work. Salary $150 per month.

1011 A young man with technical training, who has had two or three years experience in the construction or operation of gas plants or gas plant machinery, wanted by a manufacturing firm in Midddle West for installation work in this country on a new high-grade apparatus used in the gas industry. Good opportunity for the right man. Apply through the Society.

1012 Plant manager with executive ability and tact, to be jointly responsible with superintendent, for physical equipment and high grade efficiency of two plants in New York State. Prefer man at beginning of career rather than with established position at advanced salary. Apply through Society.

1013 Gas engineer familiar with electrical work, would prefer a young man member of the Society, with a few years practical experience.

1014 Assistant superintendent with qualification to develop into Superintendent. Experienced on moderately heavy work, as machine tool building, with good knowledge and experience in tools, jigs, and fixtures, heat treatment for tool steel and cutting feeds and speeds for working both cast-iron and cast steel. Some knowledge of electrical work beneficial but not necessary, must be capable of adjustment to piece-work shop. Apply through Society. Location New Jersey.

1021 Efficiency engineer familiar with technology of steel industry. Must be competent to carry entire proposition. Apply through Society.

MEN AVAILABLE

300 Member, age 36, ten years designing and building steam, electric and gasolene hoists for contractors, railroad and mine work. Good manager and systematizer, accustomed to handling men; wants similar position requiring executive ability preferably in the West. At present employed. Can furnish first-class references.

301 Member, technical graduate, 31 years of age, desires to locate with company of consulting engineers or corporation as works manager, me-

chanical superintendent and efficiency expert, wide experience in central station work, designing, purchasing equipment, superintending installations, construction and operating departments; accustomed to consulting work in the investigation of power production in relation to isolated plants for large corporations. Also experienced in mill and reinforced concrete construction work.

302 Member, age 36, at present employed, desires change. Experienced in the design of engines and boilers, steam power plants, structural steel and general engineering; has executive ability. Position must offer fair salary to start and advancement.

303 Member, age 33, technical graduate now employed, desires change. Ten years experience in mill engineering and central station work consisting of designing, specifications, buying equipment, supervision of installation, management of operation and maintenance. Accustomed to handling high-grade men. Would like position as plant engineer or with consulting engineers. Excellent references.

304 Member, 37 years of age, 17 years practical manufacturing experience as workman, draftsman, foreman and superintendent with concerns manufacturing steam appliances, automatic machinery, sheet metal, brass rod and wire goods. Short experience in Great Britain supervising manufacture of machinery. Considerable experience in factory organization work. Desires position as factory executive.

305 Sales manager has handled successfully well-known accounts, practical, systematic, good correspondent and estimator. Will accept the responsibility necessary for the entire management of the office, or will handle the account for New York and the East. Broad acquaintance in the engineering, contracting and manufacturing field. Competent to establish foreign products in the United States.

306 Junior member, age 32, desires immediate connection. Twelve years experience, five years gas engine drafting, detailing, designing, checking; three years special machinery, designing, overseeing; two years refrigerating machinery; one year costs, systematizer, time-study; shop foreman, assistant master mechanic. Prefers New York district; alert, capable, efficient, quiet. Salary $1800.

307 Graduate mechanical engineer. Junior member, two years teaching mechanical engineering subjects, two years designing and drafting on mechanical and structural work. At present instructor in machine design. Desires position as chief engineer or works engineer for shop in Middle West.

308 Member, age 42, desires position as assistant manager or general superintendent; practical mechanic, 23 years experience in office, stores and shop in the manufacture of internal-combustion engines, stationary and tractor, marine engines, steam and power pumps, mining machinery steam and locomotive work, electric motors, transformers and starting devices. Design and erection shop and foundry buildings, steam, electric, pneumatic and hydraulic power plants. Competent to assume full charge.

309 Sales engineer desires position where a knowledge of machinery and mill supply trade in United States and Canada is essential; seven years varied engineering experience, nine years in selling end. Experience in correspondence and design of selling contracts.

310 Graduate M. E., age 27, married; three years experience with large construction firm, three years experience in mechanical and engineering departments of large industrial plant. Desires to locate in East. At present employed.

311 Technical graduate desires position requiring engineering, executive or confidential ability, or to become associated with a firm of consulting purchasing or inspecting engineers; practical manufacturing experience in iron and steel castings and machinery; can thoroughly satisfy anyone looking for a man of exceptional experience and ability.

312 Factory manager, member, technical graduate, thoroughly familiar with both the Taylor and Emerson systems of scientific management, possessing considerable executive ability, initiative, self reliance and tact in the handling of men, desires position where increased production at a decreased cost is the prime object. Best references; at present employed.

313 Junior, age 25, graduate mechanical engineer, five years experience in design and manufacture of marine and stationary gasolene and oil engines. At present employed; will consider any proposition having opportunity for advancement.

314 Member; now employed, with 17 years experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, graduate Massachusetts Institute of Technology in mechanical engineering, post graduate course in electrical engineering, desires permanent position in New York City, salary to start $4000.

315 Member desires position as works manager, superintendent or mechanical engineer; competent to organize all departments of manufacturing plant along modern lines, long experience, best reference.

316 Executive engineer, $8000 diplomatic progressive business man. Education technical and legal; wide experience in designing and operating large metallurgical, chemical and manufacturing plants, consulting and purchasing, unsurpassed references.

317 Student member desires part time work, New York or New Jersey.

318 Graduate mechanical engineer, four years experience in woodenware and wood-working business, desires position as superintendent large manufacturing concern or production engineer where exprience in handling labor and designing special machinery is required. At present employed, married, salary $200. Location, Middle West preferred.

319 Junior member, age 28, technical graduate, aggressive and energetic, has tact and proven business ability, experienced in shop, design and efficiency engineering, desires position connected with efficiency and scientific management work.

320 Member, age 35, technical training, wishes to become engineering assistant to executive of strong, growing concern, with view to taking independent responsibility; 12 years commercial experience in responsible engineering capacities; three years in charge engineering work at leading technical school. Character of work and opportunities for advancement more important than immediate compensation.

321 Member, technical graduate, age 42; over 20 years experience in manufacture of gas engines, steam, electric, and gasolene locomotives; wide experience in pattern, foundry, boiler and sheet-iron work. Familiar

with modern shop equipment, methods and management, piece work, premium plans, efficiency methods, inspection systems, etc.

322 Junior member, age 30, experienced in design, construction and superintendence of high and low-tension substations, transmission lines, etc., desires connection with large contracting firm or manufacturing plant requiring services of graduate mechanical and electrical engineer. Best references, moderate salary.

323 Junior member, age 27, technical graduate; employed by firm doing miscellaneous plate business; experienced in detailing and estimating, desires position in estimating department of company doing similar work or with contracting company.

324 Middle-aged man with technical education; experienced in manufacturing problems, design, construction of special machinery and tools for more efficient production. Could offer line of punching and stamping presses with distinctive features.

325 Member, 15 years engineering experience, desires position as purchasing agent; 6 years experience specifying, buying and inspecting. Present salary $2400.

326 Member, master's degree from Cornell, desires position as electrical, mechanical or efficiency engineer, purchasing agent or manager of an industrial plant. Has had 20 years experience, designing, constructing, operating and managing. Can give best of references.

327 Junior member, age 25, graduate mechanical engineer, 1911, broad experience as factory inspector; desires position with chance for advancement. At present employed.

328 Member since 1889, 47 years of age, experience at bench and as superintendent in shops making special tools and interchangeable machinery; designing engineer in large chemical works; engineer of construction and of tests in central heating plant; university professor in mathematics and mechanical engineering; director of technical schools.

329 Member, 35 years of age, graduate of Cornell University; wide experience in design, construction and operation of power plants and other machinery; design and superintendence of mill-building construction; desires position with large corporation as supervising engineer to take complete charge of all power operation, repairs and new construction work. At present employed and will consider only high-grade position.

MEETINGS

NEW YORK MEETING, OCTOBER 14

Unusual interest was aroused at the first meeting in New York, through the introduction of the subject of Aviation as the topic for the evening. The paper was by A. A. Merrill, lecturer on Aeronautics at the Massachusetts Institute of Technology. Mr. Merrill discussed the subject of stability, and by the aid of the blackboard made a clear presentation of the elementary principles upon which stability is based. The present types of aeroplanes are decidedly unstable and the speaker contended that the subject is an engineering one which should receive greater attention on the part of trained engineers, and that more substantial progress would be realized if laboratory methods were introduced in this country, such as have been so successful in the development of flying machines in France.

The general discussion, for the most part, took the form of questions asked by the audience and answered by the speaker of the evening. Later, however, those in attendance were entertained by E. A. Sperry, and his son, L. B. Sperry, who showed lantern slides and gave a most interesting account of the practical work which they have accomplished through the use of a gyroscope in connection with Curtiss machines. Mr. E. A. Sperry held that it was not desirable to attain the degree of stability advocated by Mr. Merrill. He instanced the case of the giant ocean liners with a metacentric height of only fifteen inches—almost devoid of inherent stability. Such a construction leads to smooth riding over the rough seas, and in like manner an areoplane without inherent stability will ride more smoothly than one which through a constant change of base of the machine tosses with every change in air current in order to maintain its stability. Mr. Sperry has worked along the lines of using the gyroscope which gives a constant base line in connection with a machine which lacks the stability advocated by Mr. Merrill.

There was a written discussion by W. Wallace Core, and in his closure Mr. Merrill said that he believed an apparatus such as Mr. Sperry used would be safer and the plan would be better if the gyroscope were applied to a stable machine than to those of the present type.

WORCESTER MEETING, OCTOBER 17

In accordance with the new plan of the Boston committee, the first of the group meetings in the vicinity of that city was held in Worcester on October 17, with a total attendance of 222. A local committee, consisting of Wm. W. Bird, chairman, C. A. Read, C. M. Allen, V. E. Edwards and S. R. Riley, coöperated with the Boston committee in the very complete arrangements.

Over 100 of the Boston membership were in attendance, and the large party going by the noon train from Boston was met upon arrival with automobiles and conducted to the electrical building of the Worcester Polytechnic Institute, where luncheon was served. The party was then organized into ten different groups for the purpose of visiting the different industrial plants of Worcester. These trips included the Worcester Electric Light Company, Webster Street plant, the Reed and Prince Manufacturing Company, the American Steel and Wire Company, Quinsigamond works, Graton and Knight Manufacturing Company, the Crompton and Knowles Loom Works, the United States Envelope Company, Logan, Swift and Brigham plant, the Osgood Bradley Car Company, the Worcester Pressed Steel Company, the Heald Machine Company and the Norton Company Works.

Those who did not desire to participate in these trips were invited to attend a lecture at the institute on Aeroplane Propellers Experiments, by Prof. David L. Gallup, which took up somewhat in detail the data obtained at the institute testing plant during the two years of its operation. A demonstration in the hydraulic laboratories followed the lecture.

The entire party reassembled at four o'clock at the works of the Norton Company, where three short talks were given. The first, by Aldus C. Higgins, was confined to abrasives and was illustrated by lantern slides. Artificial abrasives, by aid of the electric furnace, are the only ones used by the company, and Mr. Higgins traced their manufacture from raw material to the crushed lumps, in which condition the abrasives are sent to the grinding wheel plant. At this point, the second speaker, Carl F. Dietz, told how modern grinding wheels are made, showing the important operations, and following a wheel from department to department by means of lantern slides. Mr. Dietz closed his talk with slides which showed the efficiency of the different abrasives on various materials and also how these efficiencies are determined.

Charles H. Norton next spoke on the use of grinding wheels, emphasizing that the modern grinding machine is a manufacturing tool by means of which it is possible to produce work rapidly of great accuracy. He had grinding samples on exhibition which showed that for low production cost the lathe must be used only as a roughing tool, leaving all the finishing to the grinding machine. An inspection of the Norton works then followed.

Dinner was served at seven o'clock in the New Bancroft Hotel, at which the senior Vice-President of the Society, Prof. Ira H. Hollis, presided, and two interesting addresses were made.

Mr. James Logan, a former mayor of Worcester, was the first speaker, and called attention to various points connected with the origin and growth of the several Worcester industries, pointing out that practically all of them had started from very modest beginnings and had grown by reason of the energy and conscientiousness of their proprietors. He especially called attention to the fact that probably none of these men had dreamed of the present proportions of the enterprises with which they had been connected, but had served the future by diligently and honestly meeting the situation before them. He also pointed out that the proper attitude for their successors was for them to consider themselves as the

trustees of the legacy which had been handed down to them, and that the prosperity of any city would be secure just in so far as such a spirit prevailed among those who controlled its industries.

The second speaker, Hon. Charles D. Washburn of the Washburn and Moen Company and president of the board of trustees of the institute, referred to the early steps in providing communications between Worcester on the one hand and Boston and Providence on the other, and spoke of the fact that in the early days the location of industries was often determined by very trifling circumstances. Some of these, while amusing, gave illustrations of the earnestness of spirit of the fathers of industry which, in a large measure, accounted for their ultimate success.

The representative character of the attendance at the meeting was especially noticeable, there being in addition to Worcester and Boston members, a large number from other parts of Massachusetts, as well as some from Rhode Island, New Hampshire and Vermont. Besides Vice-Presidents Ira M. Hollis and I. E. Moultrop, and Calvin W. Rice, Secretary of the Society, several former officers were present.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The annual smoker of the Armour Student Branch was held on September 24, the speakers of the evening being Professors Gebhardt and Paul. Their subject was the Value of Membership in an Engineering Society.

On October 16 a paper on the Power Plant of Marshall Field & Company was read by Chas. W. Naylor, Mem.Am.Soc.M.E. The subject was treated in a nontechnical manner, the elevator system, plumbing and refrigeration being especially discussed.

LEHIGH UNIVERSITY

At a meeting of the Lehigh University Mechanical Engineering Society held October 14, Professors Larkin and Butterfield, Mem.Am.Soc.M.E., were elected faculty advisors of the club. The following subjects were discussed: Refrigeration under Difficulties, R. Rankyn Galloway; Chimneys and Chimney Construction, Russel M. Neff; Dynamometers, Professor Larkin. Professor De Schweinitz and Messrs. Nachman, Nordenholt, Neff, Wright and Gift discussed the papers.

PENNSYLVANIA STATE COLLEGE

On September 26 the Pennsylvania Student Branch held its first meeting of the year in the club room of the Engineering Building. There was a large attendance of students and the work for the year was outlined by H. L. Swift, chairman of the section. In future most of the meetings are to be addressed by student members, after which there will be a general discussion of the subject presented. Professors Moyer, Diemer, Wood and Mease, all members of the Society, gave short addresses at the meeting.

POLYTECHNIC INSTITUTE OF BROOKLYN

Prof. William D. Ennis, Mem.Am.Soc.M.E., was the speaker at the opening meeting of the Polytechnic Institute Student Section, held October 4. He reviewed the work of the mechanical engineering department for the

past year, noted improvements, and referred to the work of some of the more prominent graduates. He described also some of the problems confronting the engineering world of to-day, in particular the utilization of the waste heat in engines of the internal-combustion type.

UNIVERSITY OF CALIFORNIA

At the opening meeting of the year held September 24, the University of California Student Branch elected the following officers to serve for the coming term: chairman, R. Guillon; vice-chairman, G. H. Briggs; secretary, P. H. Landon; treasurer, W. N. Penniman. It was decided to hold meetings every two weeks at which two of the student members are to give short talks upon engineering subjects to be followed by a general discussion by the members. The papers read at this opening session were: The Design of an Intake Manifold for a Gas Engine, J. C. Blair; The Automobile Self-Starter, R. Guillon.

On October 8 two papers were read as follows: Sugar in Honolulu, by G. A. Bush, with special emphasis on the machinery and mills used in this line of industry; Air Brakes, by W. E. Dean, with particular reference to their application to the railroads of to-day.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch was addressed on September 30 by A. L. De Leeuw, Mem.Am.Soc.M.E. His subject was Some Recent Developments in Methods of Cutting Metals, and the lecture was greatly increased in value by the use of unique lantern slides, and the exhibition of tools of his own design. One lathe tool gave white unoxidized chips when used on work having a periphery velocity of 475 ft. per min., taking a 1/16 in. dry cut and feeding 1/12 in.

UNIVERSITY OF MISSOURI

At the October 13 meeting of the University of Missouri Student Branch Prof. J. R. Wharton reported on the Third International Refrigeration Congress held in Chicago last month.

UNIVERSITY OF NEBRASKA

The first meeting of the year of the University of Nebraska Student Branch was called to order on October 7, and was entirely given over to the matter of future plans for the society. J. E. Brown was appointed chairman of a new members committee; J. D. Hoffman, Mem.Am.Soc.M.E., outlined the great benefits to be derived from membership in the Society, and urged all to take an active interest in its work; A. A. Luebs spoke of the value of the Transactions of the Society, and C. A. Hauptman seconded Professor Hoffman's remarks, asking all to help make the section a live one. It was announced that the meetings of December 17 and April 15 would be held before the Engineering Society.

OFFICERS AND COUNCIL

President

W. F. M. Goss

Vice-Presidents

Terms expire 1913	Terms expire 1914
Wm. F. Durand	James Hartness
Ira N. Hollis	I. E. Moultrop
Thos. B. Stearns	H. G. Stott

Managers

Terms expire 1913	Terms expire 1914	Terms expire 1915
D. F. Crawford	Chas. J. Davidson	W. B. Jackson
Stanley G. Flagg, Jr.	Henry Hess	H. M. Leland
E. B. Katte	Geo. A. Orrok	Alfred Noble

Past-Presidents

Members of the Council for 1913

M. L. Holman		George Westinghouse
Jesse M. Smith	Alex. C. Humphreys	E. D. Meier

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

F. R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

W. F. M. Goss, *Chmn.*	E. D. Meier
Alex. C. Humphreys, *V-Chmn.*	Geo. A. Orrok
E. B. Katte	H. G. Stott

STANDING COMMITTEES

Finance

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W. H. Marshall (2)
H. L. Doherty (3)
W. L. Saunders (4)
W. D. Sargent (5)

Meetings

H. de B. Parsons (1), *Chmn.*
L. P. Alford (2)
H. E. Longwell (3)
H. L. Gantt (4)
R. H. Fernald (5)

Publication

G. I. Rockwood (1) *Chmn.*
G. M. Basford (2)
C. I. Earll (3)
I. E. Moultrop (4)
F. R. Low (5)

Membership

Hosea Webster (1), *Chmn.*
Theodore Stebbins (2)
W. H. Boehm (3)
H. C. Meyer, Jr. (4)
L. R. Pomeroy (5)

Library

L. Waldo (4), *Chmn.*
C. L. Clarke (1)
Alfred Noble (2)
W. M. McFarland (3)
The Secretary

Research

R. H. Rice (4), *Chmn.*
L. S. Marks (1)
A. L. De Leeuw (2)
Rolla C. Carpenter (3)
R. D. Mershon (5)

House

E. Van Winkle (1), *Chmn.*
H. R. Cobleigh (2)
S. D. Collett (3)
W. N. Dickinson (4)
F. A. Scheffler (5)

Public Relations

J. M. Dodge (3), *Chmn.*
J. W. Lieb, Jr. (1)
F. J. Miller (2)
W. R. Warner (4)
G. M. Brill (5)

SOCIETY REPRESENTATIVES

Engineering Education

A. C. Humphreys
F. W. Taylor

General Conference Committee of National Engineering Societies

C. W. Baker
E. D. Meier

Council of A. A. A. S.

A. C. Humphreys
W. B. Jackson

John Fritz Medal

H. R. Towne (1)
J. A. Brashear (2)
F. R. Hutton (3)
J. R. Freeman (4)

Trustees U. E. S.

A. C. Humphreys (1)
F. J. Miller (2)
Jesse M. Smith (3)

SPECIAL COMMITTEES

Research Committee, Sub-Committee on Steam

R. H. Rice, *Chmn.*
C. J. Bacon
E. J. Berg
W. D. Ennis
L. S. Marks
J. F. M. Patitz

Power Tests

G. H. Barrus, *Chmn.*
E. T. Adams
L. P. Breckenridge
D. S. Jacobus
William Kent
E. F. Miller
Arthur West
A. C. Wood

Pipe Thread Gages

E. D. Meier, *Chmn.*
George M. Bond
A. M. Houser
J. C. Meloon
Chas. A. Olson
Peter C. Patterson
Henry G. Stott

Student Branches

F. R. Hutton, *Chmn.*
Wm. Kent
Geo. A. Orrok

Research Committee. Sub-Committee on Materials of Electrical Engineering

R. D. Mershon

Note—Numbers in parentheses indicate number of years the member has yet to serve.

SPECIAL COMMITTEES—*Continued*

Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for Care of Same in Service

J. A. Stevens, *Chmn.*
W. H. Boehm
R. C. Carpenter
Richard Hammond
C. L. Huston
H. C. Meinholtz
E. F. Miller

Tolerances in Screw Thread Fits

L. D. Burlingame, *Chmn.*
Elwood Burdsall
F. G. Coburn
F. H. Colvin
A. A. Fuller
James Hartness
H. M. Leland
W. R. Porter
F. O. Wells

Conference Committee on Engineering Standards

H. G. Stott, *Chmn.*
A. F. Ganz
Carl Schwartz

Society History

J. E. Sweet, *Chmn.*
F. R. Hutton, *Secy.*
H. H. Suplee

Committee on International Engineering Congress 1915

The President
The Secretary
W. F. Durand
R. S. Moore
T. W. Ransom
C. R. Weymouth

Pipe Threads

E. M. Herr, *Chmn.*
W. J. Baldwin
G. M. Bond
S. G. Flagg, Jr.

L. V. Benet, *Paris Rep.*

Flanges

H. G. Stott, *Chmn.*
A. C. Ashton
A. R. Baylis
W. M. McFarland
Wm. Schwanhausser
J. P. Sparrow

Committee on Bureau of Information Respecting Engineering Standards in all Countries

Henry Hess, *Chmn.*
J. H. Barr
Charles Day
C. J. Davidson
Carl Schwartz

Research Committee. Sub-Committee on Safety Valves

P. G. Darling, *Chmn.*
H. D. Gordon
E. F. Miller
F. L. Pryor
F. M. Whyte

Committee on National Museum

E. D. Meier, *Chmn.*
G. F. Kunz
George Mesta
H. G. Reist
Ambrose Swasey

Standard Cross-Section Symbols

H. deB. Parsons, *Chmn.*
F. deR. Furman
A. E. Norton
Bradley Stoughton
John W. Upp

Changes in the Patent Laws of U. S.

W. H. Blauvelt
Carl Thomas
B. F. Wood
Edward Weston
W. E. Winship

Code of Ethics

C. W. Baker, *Chmn.*
C. T. Main
E. D. Meier
Spencer Miller
C. R. Richards

Refrigeration

D. S. Jacobus, *Chmn.*
P. De C. Ball
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Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	H. E. Erickson	A. N. Koch
Carnegie Inst. of Tech.	Oct. 14, 1913			
Case School of Applied Science	Feb. 14, 1913	F. H. Vose	H. C. Mummert	C. Stemm
Columbia University	Nov. 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen
Cornell University	Dec. 4, 1908	R. C. Carpenter	J. G. Miller	Edw. Mendenhall
Lehigh University	June 2, 1911	P.B. de Schweinitz	W. C. Owen	T. G. Shaffer
Leland Stanford Jr. Univ.	Mar. 9, 1909	W. F. Durand	C. T. Keefer	K. J. Marshall
Mass. Inst. of Tech.	Nov. 9, 1909	E. F. Miller	W. H. Treat	L. L. Downing
New York University	Nov. 9, 1909	C. E. Houghton		
Ohio State University	Jan. 10, 1911	Wm. T. Magruder	R. H. Neilan	R. M. Powell
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Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	E. Kneass	R. F. Fox
State Univ. of Iowa	Apr. 11, 1913	R. S. Wilbur	F. H. Guldner	C. S. Thompson
State Univ. of Kentucky	Jan. 10, 1911	F. P. Anderson	R. R. Taliaferro	F. J. Forsyth
Stevens Inst. of Tech.	Dec. 4, 1908	Alex. C. Humphreys	L. F. Bayer	C. H. Colvin
Syracuse University	Dec. 3, 1911	W. E. Ninde	O. W. Sanderson	R. A. Sherwood
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Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	A. H. Aagaard	H. E. Austin
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Univ. of Nebraska	Dec. 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh
Univ. of Wisconsin	Nov. 9, 1909	A. G. Christie	W. K. Fitch	J. W. Griswold
Washington University	Mar. 10, 1911	E. L. Ohle	D. Southerland	A. Schleiffarth
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Membership in The American Society of Mechanical Engineers affords the privilege of engaging in the broad work of the advancement of the engineering profession, as well as the distinct advantage of the personal benefits accruing from such affiliation. The development of acquaintanceships at the meetings and the mutual interchange of information are also of value.

The 1913 Annual Meeting will be held December 2–5 inclusive and its program embraces a variety of subjects of importance to the numerous industries of the country (see page 4).

Your attention is called to the excellent opportunity afforded by the Annual Meeting to extend the hospitality of the Society to your professional associates and acquaintances and incidentally secure their interest in applying for membership.

Upon request invitations will be sent.

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